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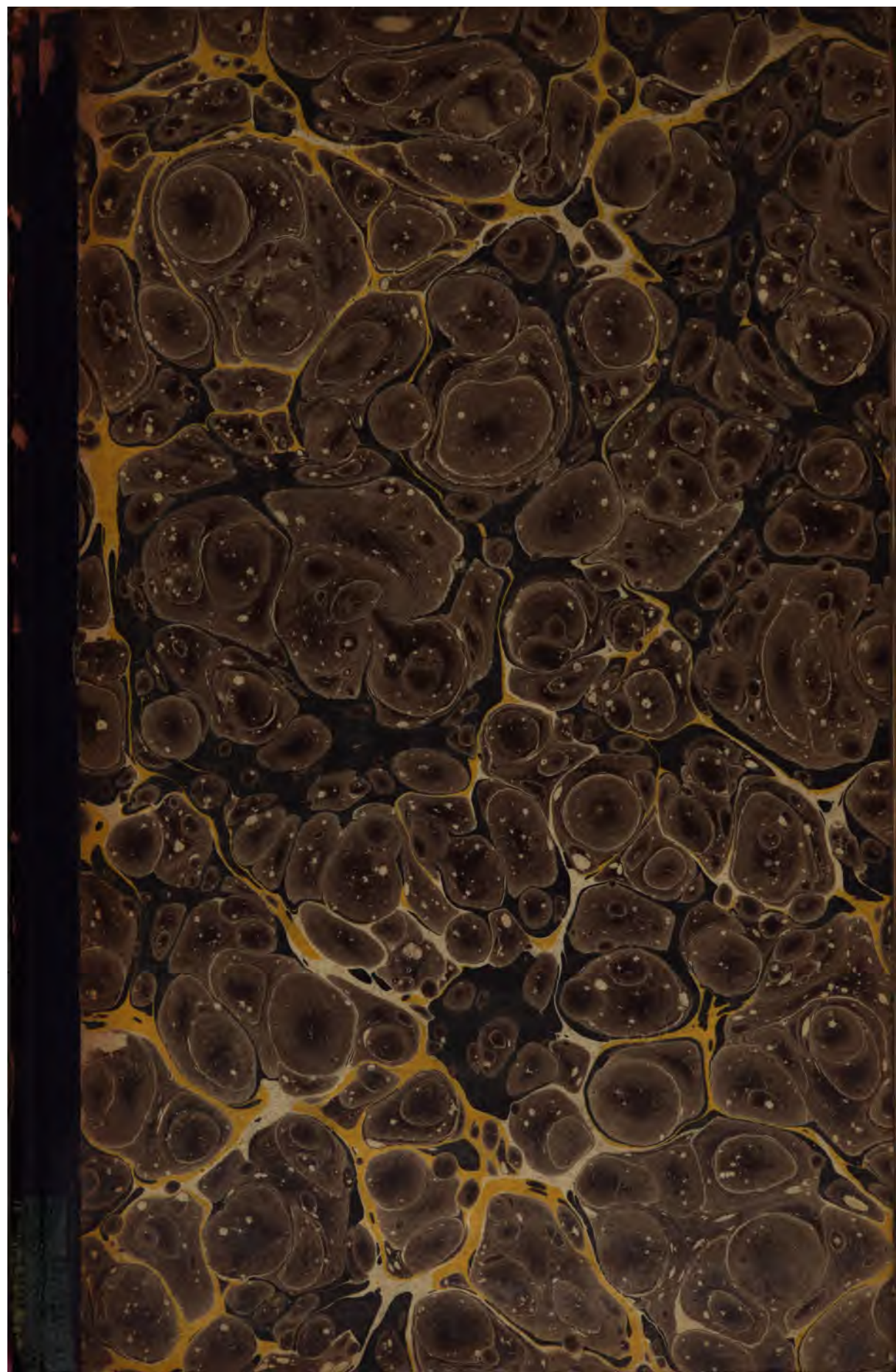
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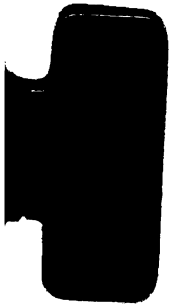
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LAND DRAINAGE

AND

DRAINAGE SYSTEMS.

A PAPER READ BEFORE THE LONDON CENTRAL FARMERS' CLUB,
DECEMBER 5, 1854,

*"On the Results arrived at from the several systems of Drainage
in practice during the last few years."*

WITH ADDITIONS.

BY

J. BAILEY DENTON, F.G.S.,

ASSOC. INST. C.E.

23

LONDON:

JAMES RIDGWAY, 169, PICCADILLY.

1855.

Price Two Shillings and Sixpence.

191. L. 57.

LONDON :
BRADBURY AND EVANS, PRINTERS, WHITEFRIARS.

TO

HENRY KER SEYMER, ESQ., M.P.,

ETC., ETC.

DEAR SIR,

I AM much gratified by your permission to address to you a Paper only partially read before the London Central Farmers' Club on *Land Drainage and Drainage Systems*, because it affords me the opportunity, first, to bring under your notice the opinions I have ventured publicly to express; and, secondly, regarding effective Arterial Drainage as the only true foundation of Systematic Drainage, it enables me thus publicly to offer to you my humble acknowledgments for the distinguished services rendered to Agriculture in conducting through the House of Commons the most useful measure ever introduced into Parliament on the subject,—though we have all to regret that the national boon which that measure would have secured was denied by the House of Lords.

Knowing how my time is occupied in active operations, I am sure your kindness will overlook imperfections which a practised writer would not have committed.

I beg to remain,

Dear Sir,

Your very faithful servant,

J. BAILEY DENTON.

52, PARLIAMENT STREET,

December 22nd, 1854.

The writer of the following Paper will be thankful for any information, or corrections, which may occur to the minds of those persons who read it. It is his intention to resume the subject at a future time.

LAND DRAINAGE

AND

DRAINAGE SYSTEMS.

ALTHOUGH perhaps no subject connected with Agriculture has been more frequently discussed than the Drainage of Land, yet it is quite certain that nothing could tend more to the general benefit of the country, than a clear exposition of the experience of the last few years, during which time so much has been done towards the establishment of principles to guide future operations.

It is to be presumed that the managing committee of this club and their chairman, Mr. Fisher Hobbs (whom I much regret to find absent from that place which he so profitably filled at the time this subject was selected for discussion), concurred in this view, and considered the present a ripe and opportune time for testing those practices and theories which have prevailed to a greater or less extent during the period referred to, or they would not have selected so vexed a question as a topic for discussion.

It is the knowledge of the differences of opinion that have existed, and still exist, that induces me to pause on my own behalf before I enter upon the subject of discussion.

I have been connected with drainage sufficiently long to be a witness of the complete overthrow of several opinions which have prevailed for a time; and I am bound to acknowledge that every day's experience, while strengthening some views and modifying

others, is proving to me that I have been as frequently wrong as the rest of my brethren, and that after all the intelligence and outlay that have been brought to bear on the subject, there is yet much to learn ere it can be said that we are perfect in the art of draining. It is plain, therefore, that we ought still to receive with respect opinions based on experience, even though those opinions may differ from our own.

It is unfortunate for those who are practising an art upon which there is so much room for controversy, and who venture to express the convictions upon which they are basing their practice, that they frequently adopt too decided terms in advancing their own opinions, and in opposing those of others.

I feel myself so likely to be guilty of this fault, that I desire to ask your excuse before I commit it.

These prefatory remarks, though egotistical, will appear more in place when it is shown that the commission of this very error has led to the adoption of practices which have, in their turn, been designated systems, simply because, in some point or other, and under varying circumstances, it has been found necessary to reject the detail of rival theories, or to modify the rules so rigidly insisted upon.

Reverting to the year 1846, in which the first act, authorising "*the advance of public money to promote the improvement of land by works of drainage*," was passed, we find all recorded opinions of any worth (except those of Elkington, which related to spring drainage,) to be in support of, and to merge into, the views advocated by either Smith of Deanston (who was the first acknowledged advocate of systematic drainage), or by Josiah Parkes, whose philosophical publications on the same subject gave a scientific bearing to it quite irreconcilable with the more mechanical rules laid down by Mr. Smith.

The characteristic views of Smith were,—

- 1st. *Frequent drains at intervals of from ten to twenty-four feet.*
- 2nd. *Shallow depth—not exceeding thirty inches—designed for the single purpose of freeing that depth of soil from stagnant and injurious water.*
- 3rd. "*Parallel drains at regular distances*, carried throughout the whole field, without reference to the wet and dry appearance of portions of the field,"

in order "to provide frequent opportunities for the water *rising from* below and falling on the surface to pass freely and completely off."

4th. *Direction of the minor drains* "down the steep," and that of the mains along the bottom of the chief hollow; tributary mains being provided for the lesser hollows.

The reason assigned for the minor drains following the line of steepest descent, was, that "the stratification generally lies in sheets at an angle to the surface." *

5th. *As to material*—Stones preferred to tiles and pipes.

The characteristic views of Parkes, at that time, were,—

1st. *Less frequent drains*, at intervals varying from twenty-one to fifty feet, *with preference for wide intervals.*

2nd. *Deeper drains at a minimum depth of four feet*, designed with the two-fold object of not only freeing the active soil from stagnant and injurious water, but of converting the water falling on the surface into an agent for fertilising; no drainage being deemed efficient that did not both remove the water falling on the surface, and "keep down the subterranean water at a depth exceeding the power of capillary attraction to elevate it too near the surface."

3rd. *Parallel arrangement of drains*, as advocated by Smith of Deanston.

4th. *The advantage of increased depth*, as compensating for increased width between the drains.†

5th. *Pipes of an inch bore the "best known conduit"* for the parallel drains. See Evidence before Lords' Committee on Entailed Estates, 1845, Q. 67.

6th. *The cost of draining uniform clays should not exceed 3l. per acre.* See Evidence before Lords' Committee, 1845, Q. 151 and 152.

Such were the published views of the two prominent advocates of systematic drainage at that juncture of British agriculture when the Legislature constituted the Inclosure Commissioners the directors of the drainage of entailed properties and virtually of the whole kingdom, and the arbiters of contested opinions.

The practice of the past afforded to the Commissioners no satisfactory and conclusive precedents to guide them, and as it was necessary to lay down some rules to regulate the expenditure of

* There is no doubt that all stratification that outcrops at the surface must describe an angle with it; but Mr. Smith was wrong in asserting that the soils operated upon by drainage "generally lie in sheets." Lamination of soil is found to be the exception, not the rule.

† See Questions 57 *et seq.* I have reason for believing that Mr. Parkes did not intend his evidence should be interpreted according to the deduction here expressed. He spoke more of the practices of others than of his own.

money chargeable on future generations, they were bound to adopt such as appeared to them best calculated to secure permanent and economical work, although those principles were based on modern philosophy rather than past usage.

Mr. Smith's, or the "shallow system," aiming only at getting rid of the enemy, was most popular in the country, because the object was simple, and it more nearly approximated to past practice. Mr. Parkes's, or the "deep system," on the contrary, aiming at the conversion of the enemy into a friend, was only acknowledged in the first instance by the few whom his most admirable "Essay on the Philosophy of Draining" had converted to his views. The Commissioners recommended for adoption the main principle of Mr. Parkes's system—*increased depth*—and without pledging themselves to the details, left much to the good sense of land-owners, the judgment of their inspectors, and the general progress of knowledge on the subject.

It was absurd to suppose, although it has frequently been asserted to be the case, that the Inclosure Commissioners, in preferring deep to shallow drainage, necessarily adopted Mr. Parkes's views with respect to one-inch pipes, (pencil-cases, as Smith used to call them,)—the deduction that depth governs distance in clay soils,—or the fallacious and mischievous assumption, that effective draining of the average of soils may be executed for less than 3*l.* an acre.

Those who have been in communication with the Commissioners know that they are incapable of prescribing such fallacies.

How much it is to be regretted that *extreme cheapness* in the permanent work of drainage ever found so powerful an advocate as Mr. Parkes, and how much more is it to be regretted that the false policy of such a seductive claim to the attention of land-owners has not been laid bare with the same force as that by which it was first promulgated.

Every person who has had any extent of practice in draining will bear witness to the frequency with which a landowner (whose knowledge of the subject might be limited to the reading of Mr. Parkes's writings) has met an estimate of 5*l.* or 6*l.* an acre

with the exclamation, that "Mr. Parkes says he can drain at 3*l.* an acre;" and when a distance of twenty-one or twenty-four feet apart between drains four feet deep has been recommended, the same landowner has ejaculated, "But observe the instances quoted by Mr. Parkes of four feet drainage, in the Weald clay of Kent. Mr. Parkes shows there that the work was done effectively by Mr. Hammond, at fifty feet apart, with inch-pipes, for 1*l.* 11*s.* 9*d.*."*

In the desire for economy, soils that should have been drained from eighteen to twenty-five feet apart, have been drained at from thirty to forty-five feet, and yet the average actual cost of parallel drainage, executed in Great Britain within the last eight years, will be found to be at least three times the cost instanced by Mr. Parkes, and which he gave, in 1846, as a guide to the future cost of drainage in this country.

I have laid considerable stress upon the fact that under-draining was first introduced, as a general system, under the false pretensions of extraordinary cheapness, because I consider, that to that fact, and to the influence of the overdrawn theories by which cheapness was to be attained, are to be attributed most of those errors and causes of dissatisfaction which have brought discredit on all systems.

* See Evidence before Select Committee on Entailed Estates, Q. 159 *et seq.* We should always remember that these instances were given in 1845, when deep drainage was in its infancy. In Mr. Parkes's Newcastle Lecture, in 1846, that gentleman spoke of prices "varying from 2*l.* to 5*l.* per acre," and these figures advanced, in 1848, to "from about 3*l.* to 6*l.*" See Minutes of Information, General Board of Health, page 92. It must not be assumed that these remarks are meant to convey any disrespect towards Mr. Parkes. That gentleman's services in the cause of drainage have been inestimable, and his high reputation will not be affected by any remarks which experience may suggest with reference to details, so long as the philosophical principles he first advanced in support of deep drainage are acknowledged by thinking men. The great importance of the subject under discussion, would forbid the introduction of anything so unworthy of it as *personality*, but it would appear impossible to avoid direct reference to Mr. Parkes, if we are to consider the results of *past* experience with regard to *first* cost and *permanent* return. Mr. Parkes's practice in 1854 will be found to differ very considerably from his anticipations of 1845, but the influence of his earlier writings and sayings continues to this day.

The money expended in drainage works in England, Scotland, and Wales, under the auspices of the Inclosure Commissioners, amounts at this moment (November, 1854) to 2,312,891*l.* 4*s.* 10*d.*; and I believe I am speaking pretty closely to the truth, when I state that the average cost per acre of the drainage effected by this outlay will be found to exceed 5*l.* The average of the last and present year will be nearer 6*l.* per acre.

Before we enter upon those details which characterise more or less recognised systems, let us dismiss from our minds the delusion, that the drainage executed under the control, or rather the inspection of the Inclosure Commissioners and their officers, is any peculiar system. The popular notion of "government drainage," as it is called, includes the cutting of underdrains, four feet deep, thirty feet apart, parallel with a fence, down the steepest fall of the land, and connecting these parallel lines with one main drain, following the lowest ground, and discharging at the lowest corner of the field; and there is no doubt that occasional instances do exist in which fields containing a variety of soils, and presenting a diversity of surface, have been drained in uniform parallelism from one side to the other, at an equal distance between the drains. The absurdity, however, of applying any uniform arrangement of drains as Smith advised, to cases where soil and surface both vary in character, is so manifest, that it is unnecessary to say that every Inspector in her Majesty's service would repudiate such a "system" as foreign to his practice. And with this remark, therefore, the popular idea in question may, we believe, be dismissed from the minds of all practical men.

But we cannot so readily dismiss the disadvantage of leaving to ignorant and incompetent men the performance of drainage which may be otherwise well designed. It has fallen to my lot to examine many works proclaimed to be failures, and in nearly every case I have been enabled to discover glaring defects in workmanship, which would alone explain the cause of failure without any reference to governing principles.

Such faults, however, do not detract from drainage generally, nor do they represent the particular errors of either one system

or another; for incompetency or carelessness in those who design or carry them out, will bring discredit on any system whatever.

If we as practical men desire to gain advantage from experience unwarpd by prejudice, let us look more closely into those practices which have prevailed upon estates under good management, where every effort has been made, to act upon approved scientific principles, and which afford, notwithstanding, numberless proofs of contradictory results and partial imperfections; and in order the more readily to comprehend the causes of success and failure, we will reduce to as few heads as possible the ruling principles and features of the art, and these will enable us to dispose of subordinate systems which have sprung out of local and individual practices.

It is necessary, however, that I should preface my remarks when addressing the Central Farmers' Club with the statement that I consider the execution of drainage one of a landlord's duties.

The points we shall present will be four in number, and may thus be taken—*Depth of drains—Distance between drains—Arrangement of system—Direction of drains.*

I. Depth of drains.

The evidence I have collected is so condemnatory of the shallow system of drainage, and with only one exception so much in favour of the deep system, that I consider the superiority of the latter incontestably proved.

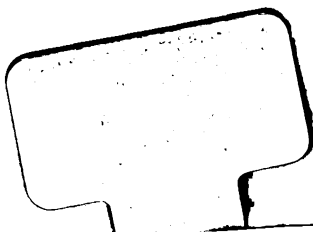
Cases without number may indeed be quoted in which the results of an indiscreet desire to economise have disproved the theory that depth will compensate for distance between drains.

Mr. George Beaumont, junr., of Bridgeford Hill, writes—

“I have had painful experience that no extra depth will compensate for too great distance between the parallel drains. I have seen drainage well executed on strong land fail miserably because it was drained thirty and thirty-six feet, when at twenty-four feet apart the drainage would be effective.”

Mr. Gow, of Morpeth, says—

“I have had one or two failures in deep draining, where, from a desire to



that the effect of deep drains in a free and porous subsoil is to diminish evaporation and raise its temperature; but there does appear to exist a considerable doubt *whether four feet drainage is sufficiently deep to "overcome succulence" and prevent excessive evaporation* from the surface of the denser clays*, and this doubt arises from the continuance of those clays to crack widely, after drainage at moderate intervals.

As the clays which exhibit these unfavourable signs are soils of less productive value, and therefore susceptible of less increase in renting return than clays of a milder description, there are many owners of such clay lands, disposed to drain deeply, who entertain the question of expediency suggested by the late Sir Robert Peel in the following words, addressed to the writer of the "Quarterly Review," No. clxxi.

"I can conceive a case in which, if you had a limited sum to expend (say 4*l.* per acre), the nature of the ground might be such, that the increased closeness might compensate for diminished depth; I mean, for instance, that drains eighteen feet apart and three feet deep, might be more effectual than drains twenty-five feet apart and four feet deep. It is utterly untrue that I am dissatisfied with the experiment of deep drainage."

* This expression is meant merely to convey an acceptance of Mr. Parkes's definition of effective draining, which he rightly says, should be sufficiently deep "to keep down the subterranean water at a depth exceeding the power of capillary attraction to elevate it too near the surface." Mr. Gisborne, in the "Quarterly Review," thus expresses himself on the same point:—"Moreover, no sooner will the soil hold water of attraction, than evaporation will begin to carry it off, and will produce the cold consequent thereon." "The system of saucer-watering is reprobated by every intelligent gardener; it is found by experience to check vegetation; besides which scarcely any cultivated plant can dip its roots into stagnant water with impunity. Exactly the process which we have described in the flower-pot is constantly in operation on an undrained retentive soil; the water-table may not be within nine inches of the surface, but in very many instances it is within a foot or eighteen inches, at which level the cold surplus oozes into some ditch or other superficial outlet. At eighteen inches attraction will, on the average of soils, act with considerable power. Here, then, you have two obnoxious principles at work, both producing cold, and the one administering to the other. The obvious remedy is to destroy their *united* action; to break through their line of communication. Remove your water of attraction, to such a depth that evaporation cannot act upon it, or but feebly. What is that depth?" That is the most difficult and the most important question connected with drainage.

Now we all know that there are thousands of acres lying on the Lias, Oxford, Kimmeridge and London clays, and I believe I may add the Wealden clay, of which the present rent in an undrained state does not exceed 10s. to 16s. per acre, and which to be drained perfectly, with reference to climate as well as soil, will require the drains to be placed from eighteen to twenty-four feet apart. We can well understand the very legitimate doubt which does and will arise to the minds of deep-draining men as to the expediency of going to the full depth in such soils—soils, which in low times, agriculturists are very disinclined to embark capital upon under any circumstances, and without which it is useless to expect a full development of the benefits of drainage. The way to understand this question clearly, is to compare cost—*irrespective of which there appears to be no hesitation in adopting the greater depth.* Let us take the case of land on the Oxford clay, which, we will assume, for argument sake, will not support an outlay exceeding 5*l.* per acre, which is equal to 7*s.* per acre rent charge for a twenty-two years' term, and compare the cost of draining it by a parallel system of twenty-seven feet intervals four feet deep, with the cost of twenty-one feet intervals three feet deep, assuming the cost of the four feet work to be 6½*d.* per rod, the cost of the three feet 4*d.* per rod, and the price of pipes for minor drains 18*s.* per thousand.

	27 × 4	21 × 3
Cutting and filling	£2 13 0	£2 1 10
Pipes	1 10 6	1 19 2
Haulage	0 4 3	0 5 5
Pipe-laying and extra for mains, clearing outfalls, iron outlets and masonry	0 11 8	0 13 0
Total	£4 19 5	£4 19 5

A gain of two yards in nine is considerably in favour of a rapid discharge of the water of drainage. But in gaining this advantage we lose the extra foot of active soil, which belongs to the four feet work. The cost of draining four feet deep at the narrow intervals, taking the same scale of prices, will be 6*l.* 6*s.* 8*d.*,* but

* See Table I.

this proposition, though the right one, would involve an expenditure of 1*l.* 6*s.* 8*d.* more than it was assumed the land would bear, and it is therefore beyond the present question, which is limited to the simple comparison of effects produced by a given outlay.

It is not however to be inferred from these observations that we are to suppose that the Legislature contemplated that land previously rented at 10*s.* per acre, should be raised to 17*s.* immediately after drainage, or that landowners should in all cases expect the tenants to pay the full amount of the charge by which both principal and interest may be liquidated; they are made with a view to show that if shallow drainage is sufferable at all, it is only in dense and poor clays, where a landowner desires to satisfy himself and the Government that the improved annual value exceeds the annual charge; an obligation which, it is said, prefixes the sum to be expended per acre on land of limited capabilities.

Having stated the fact that there exists a limited, though well-founded belief, that four feet drains fail to diminish evaporation from the surface, or to "overcome the succulency"* of certain clay soils, it is necessary also to affirm that there is a conviction among practical men, who fully appreciate the benefit of deep drains, that they may nevertheless be too deep as well as too shallow. That there is a depth at which clay subsoils cease to be influenced by underdrainage, is shown by nature. We find the diluvial clays which cap the high chalk hills, although but ten or fifteen feet in thickness, requiring the aëration of *frequent* drains to render them capable of percolating surface water; and we find in draining these clays, that as soon as the chalk ridges beneath are touched, away sinks the water of drainage into that basin, which has existed before, but without any sensible effect on the water upheld by the clay upon it. And this instance is only a type of many proofs that the well-sinker might adduce of the existence of a porous and dry stratum existing beneath a wet one, or of a deep clay bed being dry at twenty feet, and

* See Mr. Blamire's Evidence before Lords' Committee, Question 37, 1849.

wet at ten feet ;—in fact, in several parts of England advantage is taken of a natural drainage existing beneath wet clay soils, by concentrating the underdrains to sumpts, or holes, called “swallow-holes,” penetrating the clay into the porous stratum beneath ; but this practice appears to be open to objection, in consequence of the frequency with which the drainage waters will rise and cover the surface of the ground when the substratum refuses to absorb the water discharged from the drains with sufficient rapidity.

In our present ignorance of the state of the earth at various depths from the surface, and of the influences at work beneath to produce changes of condition, it appears to be the height of presumption to say, as it is frequently said by enthusiastic deep drainers, that drainage cannot physically be too deep. We may all observe that the force of gravitation fails to saturate, by the descent of water, clays beyond a certain depth, though we find in the adits of coal mines that the floors rise as well as the roofs sink, showing that there is either immense compression by gravitation on the earth’s substance or a pressure from beneath as well as from above, of which we cannot estimate the power. I admit my incapability to explain these phenomena.

We have referred to that class of clay lands, in which it has been deemed expedient, under circumstances, to make a compromise with principle ; it will be well now to state that there exists a strong feeling with many intelligent men, that low meadow-land should be treated differently to upland pasture, and upland pasture differently to arable land.

The description of meadow-land to which I particularly refer, is that which has a free and porous subsoil. The argument of those who advocate deep drainage in all soils without exception, is that in meadow and pasture land the effect is to displace aquatic, sour, and rank herbage by sweet, nutritious, and early grasses ; while the reply of those who take an adverse view, with respect to meadow-land, is that after you have taken a crop of hay, a full aftermath is more likely to be obtained in the months of September and October, when feed is generally scarce, by the retention of

the water level within three feet of the surface, and that any advantage you may gain by an early bite between Candlemas and May-day, on land drained more deeply, will not compensate for the loss of quantity in the autumnal months of scarcity. I believe I am right in naming Mr. Hewit Davis, as one of those who doubt the advantage of deep drainage of meadow-land of porous subsoil.

Among those who treat pasture differently from arable land, I may mention the names of the following gentlemen, who have drained extensively in the north of England:—Mr. Thomas Anderson, of Little Harle Tower; Mr. Stratton, Spinney-moor House, Durham; Mr. Gow, Morpeth; Capt. Coulson, Newborough; Sir William Lawson; the Hon. G. F. Russell. They have all increased the width between the drains, and the majority have deepened them from four to five feet with good effect. Mr. Curtis Hayward, of Quedgely, Gloucestershire, and many other landowners of the south, adopt the same practice of widening and deepening the drains. Mr. Richard Milward, of Thurgarton Priory, Notts. (who still retains his predilection for shallow drainage), and Mr. Fisher, of Melton, Northamptonshire, on the contrary, adopt a deeper drainage for arable than for pasture land.

My own observations bring me to the conclusion that it is not possible to lay pasture land too dry, for I have invariably remarked—during the recent dry summer and autumn particularly—that both in lowland meadows and upland pastures, those lands which have been most thoroughly drained by deep and frequent drains are those that have preserved the freshest and most profitable herbage, and I should not have referred so pointedly to the differences of practice prevailing, had I not observed in some of the Fen districts, that water is introduced into the ditches during the latter months of the summer, and in autumn, in order to maintain vegetation, which it is believed would otherwise prematurely dry up and decay.

This fact would seem to favour the views of those who would except meadow land, with a free subsoil, from the deep drainage system; but in contradiction to this, let me refer to a curious

circumstance favouring the opposite view. During the wind storms of the past summer a great many trees were blown down in various parts of the country, and it was observed that the trees in the flat valleys suffered most, and I remarked in the valleys of the Test and Anton, in Hampshire, and in that of the Trent, in Staffordshire, that the numerous trees blown down exposed to view a flat bottom of roots, which had evidently fitted to the surface of the water level in the land of the valleys, and I found by the aid of a spirit level, that although the depth of soil attached to the roots was different with different trees, the height of the flat base upon which the trees so insecurely stood was identical with the constant water level of those valleys; and I came to the conclusion that if a stagnant water base was so forbidding to the roots of trees, it could not be very wholesome for perennial grasses, for it was evident that vitality ceased when the roots reached the standing water-line.

But there is a method which will meet the requirements of those who desire to prolong through the autumnal months the growth of their meadow grass, without encouraging aquatic vegetation, and without any compromise of the principle of depth. I refer to the practice of using the drains, which are primarily intended for freeing the soil of injurious water during winter, spring, and early summer, for the secondary purpose of sub-irrigating the soil during the latter end of summer and autumn, by letting water pass through the drains from a higher level into the soil, or, by plugging the outlets, and contriving to retain whatever water will rise up within it and would otherwise be discharged by the drains.

This application of water from a higher level is found to be much enhanced in value, when the source of supply is calcareous, and the meadows to which it is applied inclined to peat.

I submit that upon the first point, *depth*, the results of the practice of the last few years have confirmed the soundness of the principle of a minimum depth of four feet, where outfalls will admit of it.

II. *Distance between drains.*—The indiscriminate adoption of the theory, that the *deeper* the drains the *wider* may be the intervals between them, has brought more discredit upon systematic draining than any other rule which has been put in practice for the furtherance of economy: and the unsatisfactory results that have followed its adoption on the stiffer clays and in humid localities, have caused not only the promulgation of new designs, or systems, but increased earnestness with those few who still advocate a shallower minimum depth than four feet. Mr. Parkes, I believe, started this theory;—a desire to keep down the cost of drainage works has maintained it in practice;—and for the same reason it will be continued in practice by those who have limited opportunity of observation, until the necessity of inserting intermediate drains shall have convinced every one that such work is the most expensive of all works.

Already have Lord Wharnccliffe, Lord Fortescue, Mr. Barnett, of Stratton Park, Beds., and, I believe, other landowners, adopted the mixed system of deep and shallow drains as an amendment of the excessively wide system; but this method is so clearly one of expediency (as a statement with which Lord Fortescue has favoured me will enable me to show), that it can never be recognised as a system worthy to supersede an adequately and uniformly deep system, however it may be justified as an amendment of an unduly wide one.

When we find the same width and depth adopted in the drainage of clays of different properties, such as the London clay of Essex compared with the coal measures of Yorkshire and Lancashire, and when we find the same rule applied to clays of the same formations and properties in localities differing in the depth of rainfall, and in the duration of wet weather, such as the lias clay of the east coast of Yorkshire, and the same clay of the south coast of Dorset, the coincidences imply inconsistency of practice, if nothing worse.

It is true, that when we look closely into the several clays which characterise different geological formations, we find that the closer and more difficult clays to deal with, are to be found in

the south-eastern portion of England, where the rain-fall is less, while the more open and more easily drained soils pervade the northern and western portions of the country, where the rain-fall is greater and the periods of rain are of longer duration than in the south-eastern districts.

To make the view clear, a line should be drawn from Whitby in Yorkshire, to Lyme Regis in Dorset-shire, following the course of the lias formation, and it will be found that the clays of the more recent strata, which outcrop towards the south-east, are generally much more dense in character than those which occur in the older formations on the west of that line. This distinction, however, is partially, if not wholly, counteracted by the largely increased fall of rain, or an increased number of days in which rain falls.

To the west of the lias range we have, in a descending order, the following clays:—New Red-sandstone clays; the Magnesian red marl; the Coal-measure clay and Milstone grit; the Mountain limestone; the old red Sandstone clay; and the Greywacke beds. All these, with the exception of peculiar layers, are comparatively open soils hardly dignified by brickmakers with the name of “clay.” The rain-fall will be found to increase as these strata outcrop westward. Thus, at Derby, immediately west of the lias range, the rain-fall is twenty-seven inches; at Manchester thirty-six inches; and at Tavistock, in the west, 53·6, and at Kendal, in the north, fifty-eight inches.

To the east of the lias range, we have in ascending order the following clays—lias of different qualities; the Oxford and Kimmeridge or oolitic clays of different qualities, the Wealden, the gault of the greensand, the plastic and London clays, and the diluvial and alluvial clays of the more recent deposits. Most of these are truly “clays”* in an agricultural sense, and the rain-

* It is hard to define a “clay,” as will be seen by comparing the analyses in the accompanying table, in which the proportions of clay differ so widely; but we should not be wrong in taking 50 per cent. (by Professor Way’s analysis) as a proportion distinguishing a “clay” from a loam. An intelligent though uneducated foreman of Draining, who had been both a brickmaker and a well-sinker, in speaking of the *lias* clay, said: “This is a clay and

fall acting upon them will be found to be much less in quantity, and to vary much less than that to the westward. Thus we have at Oxford twenty-two inches, and at Bedford twenty-seven, at Cambridge twenty inches, and at Thetford nineteen inches, at Epping twenty-six inches.

We find, from sundry careful records, that one hundred and forty-one inches may be taken as the average annual rain-fall of the wettest place* in the north-west of England, while nineteen and a half inches may be taken as the average fall of the south-eastern district. And we find that the average number of days in the year in which rain falls in the wettest districts is two hundred and ten, while at Chiswick (which we are obliged to take for want of records from more eastward places) the average number of wet days in the year is one hundred and twenty-four, with an average fall of twenty-four inches.

These facts afford some reason for the apparent inconsistency of draining the comparatively open soils of the north and west, by the same rule with respect to width of intervals as the closer clays of the south-east; but it does not explain why the lias clay in the dryer climate of the north-east of England should be treated precisely like the same clay in the humid atmosphere of the south-west.

The opinion that the soils most frequently called clays in the north of England and in Scotland are comparatively "loams," may be received by my northern brethren with derision; but examination will prove that so far as any general distinctions will apply, the opinion expressed is well-founded. Of course there are exceptions in this instance, as in all other general rules. These exceptions are to be found in some slowly deposited clay

no mistake, and the 'awkwardist' stuff a man can deal with. It wants a deal of humouring. A clay like this, compared with some stuffs they call 'clay,' is like a pig compared with other animals. There's no driving either, sir; they have each a way of their own." And this man's description of a "clay" is not only trite, but true.

* I quote these extraordinary figures from the transactions of the Royal Society as an *extreme*, and I must beg they will be so read. In giving this explanation, I would impress upon all the fact, that it can only be by having due regard to specialities that effective drainage can be attained.

TABULAR STATEMENT OF ANALYSES OF DIFFERENT CLAY-SOILS.

Geological description of soil.	Locality.	Average annual rain-fall.	Average annual number of days on which rain falls.	Weight of sample dried by exposure to air and sun.	Weight after four days' absorption of water placed within reach of suction. Sept. 26, 1854.	oz. dec.	Difference in weight between dry and wet.	Weight immediately after pressure of sample by 6 cwt. into rectangular block 3 inches square. Sept. 29, 1854.	Weight after exposure to air and sun. Oct. 7, 1854.	Proportion of weight lost by evaporation.	Measure of breadth and depth of rectangular block immediately after pressure. Sept. 29, 1854.	Measure after exposure to air and sun. Oct. 7, 1854.	Proportion of external measure diminished by contraction.	Proportion of weight absorbed from the atmosphere after being broken small and dried in an oven. Dec. 2, 1854.	In 100 parts.			
															Organic matter and combined water.	Sand.	Clay.	Lime.
1. Diluvial warp clay.	Portbury, Somersetshire.	..	..	12	16-00	oz. dec.	4-00	14-96	11-96	1	4-283	4-068	1	1	5-47	12-35	79-89	2-79
2. London clay.	Regent's park, Middlesex.	26	124	12	17-50	5-50	15-20	12-0	11-95	1	4-667	4-133	1	1	1-46	10-07	14-57	78-90
3. Wealden clay	Maresfield, Sussex.	..	..	12	15-57	3-57	14-20	11-95	..	1	4-470	4-050	1	1	4-81	6-92	79-41	8-86
4. Drift chalk on Kimmeridge clay, called "white clay".	near Horncastle, Lincolnshire.	..	..	12	14-75	2-75	14-00	11-98	..	1	4-800	4-066	1	1	2-05	36-52	56-74	4-69
5. Boulder clay on Oxford clay.	Haddon, Hunts.	..	..	12	17-06	5-06	15-85	12-0	..	1	4-400	4-060	1	1	4-70	6-80	84-34	4-16
6. Oxford clay with covering of warp-drift.	Orton, near Peterborough.	..	..	12	15-42	3-42	14-17	11-97	..	1	4-570	4-180	1	1	2-60	11-12	84-08	2-25
7. Lias clay.	Vale of Belvoir, Lincolnshire.	..	..	12	18-62	3-62	15-35	11-95	..	1	4-650	4-220	1	1	..	..	..	..
8. Red sandstone from very stiff clay bed.	near Warwick.	..	..	12	17-20	5-20	16-75	12-0	..	1	4-375	4-218	1	1	..	..	..	..
9.	Lord Fortescue's estate,	..	191	12	15-19	3-19	14-98	11-98	..	1	4-500	4-500	1	1	..	..	..	..
10.	North Devon.	..	..	12	15-19	3-19	14-92	11-97	..	1	..	..	..	..	..	..	..	..
11.	Peat.	..	..	12	22-00	10-0	..	..	..	1	..	..	..	..	..	..	..	..
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

NOTE ON THE TABULAR STATEMENT OF ANALYSES OF CLAY SOILS.

This Table is published in its incomplete state, with a view to draw attention to those elementary properties and incidents of clay-soils which should guide Drainage operations. It would be invidious to quote instances in which precisely the same arbitrary distances have been adopted in the several soils here analysed; it is sufficient for the present purpose to know that drains four feet deep and thirty feet apart, have been applied to each description. Is not this fact, the inconsistency of which will be forcibly brought to the mind by comparing the fourth with the eighth analysis, a blot on the scientific progress of the present day? Surely a knowledge of the nature and constituents of clay soils, upon which millions of pounds are being spent, cannot be deemed a "profitless refinement." At this moment we have no standard determining the proportion of alumina which distinguishes "a clay soil," nor the quantity of sand which distinguishes "a loam," and I feel an anxious hope that the imperfect table here given may attract the attention of some influential member of the Royal Agricultural Society of England, to whom its details may be suggestive of more extensive information than it conveys, and who will interest the Council of that Society in the advantage of publishing a series of analyses of clay soils, of the several geological formations. I should omit a duty if I did not state that the chemical analyses inserted in the Table are furnished by Professor Way.

If we have regard to the details the Table affords, we shall be led to conclude that the elementary data expressed in Cols. 14, 15, 16, 11, 10, 12, 1, and 2, should decidedly influence Drainage operations, and much in the order in which I have taken the columns. Being no chemist, I have contented myself (on ordinary occasions) by making analyses, *mechanically*, in the following manner.

The proportions of sand (14) and clay (15) have been ascertained by washing a given quantity in a flat-bottomed medical phial. The sand will subside below the clay, and will be visible through the glass.

The existence of lime (16) has been ascertained by dropping a lump of the soil into vinegar. If it effervesces, lime exists, and if the lump dissolves very rapidly there will be a considerable proportion of lime in the soil.

The capabilities of the soil to expand and contract have been ascertained in the manner indicated at the heads of the several columns, 11, 10, and 12.

The amount of rain-fall (1) and duration of wet weather (2) have been only ascertained in a few instances from actual record.

The "grateful" nature of a soil, *i. e. its natural capability of repaying the cost of draining*, will be indicated in a great degree by its power to absorb moisture from the atmosphere. Sir Humphrey Davy said, "Where this power is great, the plant is supplied with moisture in dry seasons by the absorption of aqueous vapours from the atmosphere by the *exterior* parts of the soil during the *day*, and by both the *exterior* and *interior* during the *night*."

beds in the two red sandstones, in the coal measures, and doubtless in other formations; but they are, though consisting of many thousand acres, of comparatively very small extent, and cannot be said to characterise the geological formation in which they occur. The exceptional clays are very difficult to drain, because they not only exist under a more humid atmosphere, but receive the soakage of surrounding strata more porous than themselves.

In the table of analyses which have been prepared with a view to ascertain the comparative draining qualities of the characteristic clays of different strata, an analysis is given of a specimen of the stiffest red sandstone clay I have met with, which shows that, independent of position, it is as forbidding a clay as any surface clay we have in England.

The very general satisfaction which has attended systematic drainage, at comparatively wide intervals, in the north and north-east of England and in Scotland, is to be attributed to two causes; firstly, that when compared with the south-east, the clay soils are generally of a more open character; and, secondly, that when compared with the west of England there is a smaller amount of atmospheric humidity.

Now experience shows that a consideration of the amount of rain-fall is a matter of much moment in determining the width between drains. It does not appear, practically, to govern the size of the pipes to be used, for if the ends of the pipes can be made to join securely, and the fall is good, the smallest sized pipes will be sufficiently large. But in proportion to the rain-fall, all other consideration being equal, should be the distance of the drains apart, in order that the condition of the soil may be sufficiently free and active at all times to absorb and discharge the maximum amount that can fall on its surface.

But after we have arrived at the amount of rain-fall, we have still another enquiry to make; I refer to the number of days in which, on an average of years, rain falls.

It is not enough to ascertain the quantity of rain that falls. It is essential to a right understanding of the matter, that we should

know the prevalent periods of continuance of rain and moisture, for in accordance with the length of time intervening between rains, will be the opportunity for soils to undergo those changes of condition which are essential to complete development of drainage, and which conduce to an improved "climate of the soil itself."

Mr. Whitley says—"The number of days on which rain falls is greater on the western than the eastern coast, but the difference is not such as the relative quantity of rain would lead us to expect. The fact appears to be, that the rain-clouds brought by the south-west winds, though partially drained by the western hills, yet pervade every part of England, and deposit much of the residue of their moisture on the eastern lands."

It is remarkable how differently the rain-fall in certain districts, will be dispersed over the three hundred and sixty-five days of the year. In the west of England, where the rain-fall is considerable, an inch fall is dispersed over as many days as in the east where the fall is less, *i.e.*, over five days; while in the wettest districts of England it would appear that an inch is dispersed over only half that number of days. Now, if works of improvement, such as drainage, are to be appropriate, it is the more important that we should deal with such local peculiarities rather than with generalisms and averages. This will be manifest from the facts which the returns of 1847, the driest year on record, show:—

		Height.	Rain-fall.	Wet days.
Beckington . . .	Somerset . . .	265	28·74	151
Scathwaite . . .	Westmoreland . {	368	129·24	202
Langdale Head . .		250	112·95	209

or if we take the next year (1848) and compare the Beckington return with that from Windermere, of which the rain-fall approaches more nearly to that of Beckington, we still find the number of wet days bearing the same proportion to the amount of rain-fall.

		Height.	Rain-fall.	Wet days.
Windermere . . .	Cumberland . . .	116	72·36	230
Beckington . . .	Somersetshire . .	265	43·16	219

I consider that the figures go far to prove the deduction I have

drawn, that not only should the character of the soil and the amount of rain-fall be considered in determining the distance between drains, but regard must be had to the continuance of humidity of the atmosphere.

In the extreme western counties, the humidity of climate does not result from the quantity of rain that falls, as the returns just quoted show, but from the amount of evaporation arising from the sea, which settles upon the land during the cooler hours of the night in sufficient quantity to keep the land moist (and therefore repugnant to the development of drainage effects), and to explain the amazing number of wet days which has been quoted. If it were not for the almost constant state of vapour which envelopes the extreme west of England, so comparatively small an amount of rain as 48·16 could not be divided into two hundred and nineteen days, which is equal to an average daily fall of ·198; nor should we find moss upon all the fruit trees, and ferns running riot in every nook and corner.

Now these remarks do not apply in the same degree to the north and north-west of England, and the difference will go far to explain how success may result in the one case, and failure in the other, if treated similarly.

I submit upon the second point, *distance between drains*—that the results of the practice of the last few years have confirmed the principle, that depth may govern distance in soils of an uniformly open and porous nature; that in the denser clay soils this compensating principle is inadmissible, much clay land having been drained imperfectly from being drained too widely. In lands suffering from springs, or from a pressure of water, where each drain should be designed for a special service, there is no dependence of one drain upon another, and therefore no rule of distance whatever can apply.

III. *Arrangement of Drains*.—In order to ascertain the object of a parallel system of drainage, and the abuse to which it is subject,

we must revert to the original views advocated by Mr. Smith, of Deanston, and adopted by Mr. Parkes.

Mr. Smith advocated parallel drains at regular distances, for the following reasons. I take his own words :—

“The drains should be parallel with each other, and at regular distances, and should be carried throughout the whole field without regard to the wet and dry appearance of portions of the field, the principle of this system being the providing of frequent opportunities for the water rising from below or falling on the surface to pass freely and completely off.”

Mr. Smith, therefore, called it the “frequent drain system;” for distinction sake, I have ventured to christen this “ready made” practice the *gridiron* system.

Mr. Parkes adopted the parallel system at wider intervals, adding, that it is the subterranean water to which excessive and injurious wetness is attributable; and if such water be not removed and kept down at a depth exceeding the power of capillary attraction to elevate it too near the surface, no drainage can be efficient.

And Mr. Gisborne, in the “Quarterly,” advocated the parallel system for the reasons assigned by Mr. Parkes, christening the rain, or surface water as “top,” and the subterranean water “bottom” water, and characterising all water existing in the soil which yields to gravity, and is discharged by the drains, “*the water of drainage*,” and that which resists gravity, and is held up in the soil by capillary attraction, “*the water of attraction* ;” I do not wish to place my single views in opposition to opinions so eminent and deservedly influential as those I have quoted, but as the object we have in view is to deal practically with the subject, and to profit by the past, I do not hesitate to say that experience has to a certain extent modified if not contradicted the distinctions here quoted, and has shown that there are circumstances and positions under which parallel equidistant drains, however near, will not necessarily drain land suffering from subterranean waters.

I believe I am speaking the opinions of many practical men in denying the theory of Mr. Gisborne, that all water pervading the

soil will answer to the trite description of "the *water of drainage*," and "the *water of attraction*." It appears that there is another description of water which causes injury to land, and which, borrowing the style of phraseology adopted by Mr. Gisborne, may be called "*the water of pressure*,"—that water, which having a higher source than the land drained, rises by hydrostatic pressure, through porous veins, or by a diffused means, to the surface of certain portions of a field, to the utter disregard of any system of drains which may be economically applied to the remainder of the field.

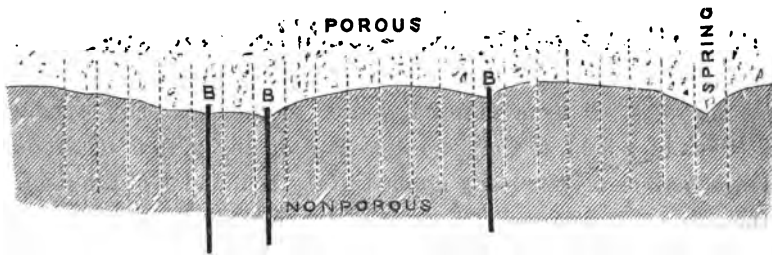
In fact, it has become daily more apparent, that to lay out parallel equidistant drains to discharge all waters rising up, or "oozing imperceptibly through the earth," is almost as costly a generalism as Mr. Smith's notion of draining a field, with variety of soil, at regular intervals throughout; for, in both cases, there must either be the throwing away of money in places where drains are not wanted, or the too scanty and inappropriate treatment of places where they are wanted.

How often is this fact brought home to us, not only by seeing wet places between drains in lands with a rapid fall of surface, but by observing, that after a vast amount of money has been expended in draining the lower lands, a perfect cure has not been effected until the higher lands have been drained also, and the water upheld in the hills let free by deep and appropriate drains, run into the water-bearing stratum, the outflow or soak of which has been, perhaps, the cause of more than half the mischief to the low land. Landowners are too apt to leave high-lying porous lands to drain themselves.

The wetness of land, which for distinction sake I have called "the *water of pressure*," like the *water of springs*,* to which it is

* Lest I should be misunderstood in thus using another term in distinguishing the water existing in *soils*, which may appear to favour the claims of those millers and water-owners who insist upon their right to all "*springs, watercourses, and water-ways*," I would desire to explain that there exists practically a clear line of distinction between the water of running springs which millers may possibly claim, and the water of pressure *existing in the soil*, which landowners may get rid of irrespective of miller's interests. Water that issues from the land in a volume either constantly, periodically, or even

nearly allied, can be effectually and cheaply removed only by drains devised for, and devoted to the object. Appropriate deep drains, at B B B, for instance,—as indicated in the dark vertical



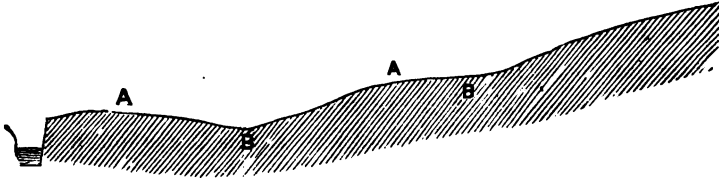
The Vertical Dotted Lines show the Position of Parallel Drains.

lines,—are found to do the service of many parallel drains, which as frequently miss as they hit those furrows or “lips,” in the horizontal out-crop of water-bearing strata which continue to exude wetness after the higher portions are dry.

A consideration, too, of the varying inclinations of surface, of which instances will frequently occur in the same field, necessitates a departure from uniformity, not in direction only, but in intervals between drains. Take, for instance, the ordinary case of a field, in which a comparatively flat space will intervene between quickly rising ground and the out-fall ditch. It is clear that the soak of the hill will pervade the soil of the lower ground, let the system of drainage adopted be what it may; and, therefore, supposing the soil of the hill and flat to be precisely alike, the existence of bottom water in a greater quantity in the lower lands than in the higher, will call for a greater number of drains. It is found, too, that an independent discharge or relief of the water coming from the hill, at B, should always be provided, in order to avoid any impediment by the slower flow of the flatter drains.

Experience shows that with few exceptions hollows or “slacks,” observable on the surface, as at B B, have a corresponding undulation of subsoil, and that any system which does not provide a intermittently, may be the property of the miller *if usage support the claim*; but water oozing through the soil and evaporating at the surface, is clearly the property of the owner of the land it injures.

direct release for water, which would otherwise collect in and draw towards these spots, is imperfect and unsatisfactory. It is



found to be much more safe to depend on relief drains than on the cutting of drains sufficiently deep through the banks, at A A, to gain a fall at a regular inclination.

Still, in spite of experience, we often observe a disregard of these facts, even in works which are otherwise well executed to a depth of four feet, but fettered by methodical rules, and I feel compelled to remark that it has often occurred to me, when I have observed with what diligent examination the rules of depth and distance have been tested, that if more attention had been paid to the *source* of injury, and to the mode of securing an effective and permanent *discharge* of the injurious water, much greater service would be done.

In the desire to get rid of drainage water, it has been discharged into the nearest field-ditches, which have become so many elongated ponds to dissipate their contents by evaporation into the air, or by soakage into lower lying grounds, little care being paid to the ultimate and permanent discharge of drainage water.

If, nevertheless, we are to profit by experience, we shall be led to modify the parallel system of arrangement by a closer attention to the variation in the texture of the soil, and in the inclination of the surface; we shall make our test-holes much more numerous; we shall look more to a subdivision of fields, which are now too frequently prejudiced by a love of mathematical uniformity; we shall cease to continue the drains of low flat-lands up the face of steep hilly ground for the sake of preserving straight lines; we shall look upon all continuous hollows, and lateral valleys, as nature's drains, which cannot be overridden by even the closest parallelism,

but must be retained as the proper course of drainage, though the conduit be in future below, as it has hitherto been above the surface; and we shall for the same reason apply distinct relief drains to those slacks or planes of lesser inclination, which constantly interpose in fields apparently of one slope and aspect, and which, when drained on one uniform plan, never fail to exhibit tell-tale spots which are not unlike a black eye on a healthy schoolboy's face: the mark of both being signs of weakness.

I submit that upon the third point—*arrangement of drains*, the result of the practices of the last few years has shown, that the principle of parallel equidistant uniformity is applicable only where there exists uniform texture of soil, and uniform inclination of surface, that it requires modification directly the soil varies and the surface becomes irregular, and that the desire for uniformity has led to waste of money and imperfect work.

IV. *Direction of Drains*.—We now come to the direction of drains, a matter which it would almost appear was decided so far as the minor drains go, if one may judge by the very general adoption of the line of greatest descent, though frequently modified by following the furrows when they are straight or nearly so, instead of crossing the ridges, in strict conformity with the parallel equidistant arrangement.

But as there are no rules without exceptions, so we find Lord Berners, at Keythorpe, crossing the fall,—and in the Greywacke districts of the West of England, where the strict parallel arrangement is inapplicable, we find that the subordinate drains, from four to eight feet deep, are frequently laid out at right angles to the stratification, and sometimes inclined diagonally, so as to intersect the substratum; and it is stated, on competent authority, with good effect.

There is reason to believe that well-selected drains led directly up the fall would in both instances do the work as effectively and economically; but of course we must hesitate to oppose a successful theory to what is alleged to be a *successful* practice.

The irresistible influence of gravitation on fluids travelling through a free soil, or along a conduit carried across the fall, is so evident to all who have studied the effect of drains so laid, and can be so easily demonstrated by observation, that it seems unnecessary to dwell on the point; but I cannot help giving an instance. Having remarked a line of moisture showing itself at the surface, at a regular distance below some drains in Warwickshire, carried across the fall, I had it in my power to ascertain the depth of the drain itself by taking the difference of height between the line of the drain at the surface and that of the line of moisture beneath it.

I recently had an opportunity in Scotland, too, of gauging the quantity of water travelling along an important drain carried obliquely across the fall, when I ascertained with certainty, that although the land through which it passed was comparatively full of water, the drain actually lost more than it gained in a passage of several chains through it.

The very general concurrence in the adoption of the line of greatest descent as the proper course for the minor drains in soils free from rock, would almost lead me to declare this as an incontrovertible principle; but we cannot so readily accept in that light the *equidistant* straight line of drains in soils where high ridges and furrows prevail.

In grass lands in the *midland* districts, the *furrows* are generally preferred by the most successful drainers; while in arable land of like character the practice with the majority is to disregard them.

In Northumberland and in Scotland, the more frequent plan is to disregard them both in pasture and arable; but then we must remember that, as before stated, the lands of the North are much more porous than the high-backed lands of Northamptonshire, Huntingdonshire, Bedfordshire, and Oxfordshire; and it would almost appear, from the remarks of some intelligent men, that if the *ridge* were selected for the drain instead of the furrow, in some soils of the North and West, even better results would accrue than if the drains were drawn across the ridge and furrow.

I observe, however, that the Rev. Thomas Witham, of Lartington

Hall, in Northumberland, whose estate is spoken of as being very well drained, states that he has followed the furrows, and that the practice is found to answer best. Mr. Stephenson, of Throckley, and Major Cadogan, of Brinkburn Priory, have done the like. Mr. Barnett mentions the very successful drainage of 150 acres at Stratton, which, being high-backed lands, were drained in the furrows two feet six inches deep, and afterwards levelled.

I have tested the efficacy of furrow draining compared with straight line equidistant draining, in the Oxford clay, and I found that in grass land much less water would rise and stand in the test-holes dug intermediate between the furrows than between the drains crossing the ridges; and during four years of observation, I have been unable to detect any difference between the two, either in the quantity or quality of the herbage. Up to this time, the anticipated superior advantage of the water percolating more generally through the soil by the straight line equidistant drains, has not manifested itself in the instance to which I refer.

In heavy grass lands, therefore, if from the position of the lands in relation to the homestead, there is no probability of their being broken up, made flat, and laid down again, experience seems to favour the adoption of drainage in the furrows.

The use of collars is by no means general, although those who have used them speak highly of their advantages. Except in sandy soils, and in those that are subject to sudden alteration of character—in some of the deposits of the Red Sandstones and in the clayey subsoils of the Bagshot sand district, for instance—collars are not found to be essential to good drainage. In the north of England, they are used but seldom, and in my opinion much less than they ought to be; but this opinion, it is right to state, is opposed in numerous instances of successful drainage by men of extensive practice; and as every cause of increased outlay is to be avoided, the value of collars as general appliances remains an open question.

In all the more porous subsoils in which collars have not been used, the more successful drainers increase the size of the pipes, in the minor drains, to a minimum size of two inches bore.

One of the most frequent errors in the systematic arrangement,

arising more from inadvertency than from reflection, is the setting out of main drains in the courses of the lowest ground, without respect to the rate of inclination at which the ground on either side falls towards that hollow. Thus, it will often be observed that a three-inch pipe, laid at an inclination of 1 in 400, will constitute the main for six or eight acres of comparatively porous land (capable of rapid percolation), of which the lateral two-inch pipe-drains may be laid at an inclination of 1 in 100. Now, if we calculate the relative capacity and power of discharge of the pipes under these circumstances, we shall find that the mean velocity of the three-inch main will be 13·60 inches per second, while that of the two-inch minor will be 24·06 inches, and that the main will discharge 3·40 cubic feet per minute, if full, while the minor drain will discharge 2·65 cubic feet per minute, if full; so that two minor drains will more than fill the main drain, although the discharge from the main may be accelerated by the pressure of water in the minor drains.

This cannot be right; and the practice is often the cause of those dark lines and patches of moisture which we see at the foot of rising ground. If the practical difficulties attending the junction of pipes as small as theory prescribes, forbid their use, and a desire of economy forbid our enlarging the mains, we have only one course open to us, which is the right one, of assimilating the fall of the main drain as nearly as possible to the fall of the minor ones.

In practice, this object will be gained by giving to each side of a valley or hollow a separate main, and inclining the head of each upwards into the rising ground. This interferes a little with uniformity, but it is nevertheless essential to good work.

Long main drains are found objectionable, and opposed to a sufficiently rapid action of any drainage system. In many instances they cannot be avoided, and then it has been found serviceable to introduce in the line of their course wells or sumpts; with relief pipes, discharging into some existing ditch at hand, so that if the mains refuse from unavoidable cause to discharge their contents sufficiently freely at their lowest outlet, the water may rise in the wells and find a ready vent by the relief drains.

I have found this contrivance very useful in the more porous strata, and I may mention a favourable instance in the drainage of The Speaker's estate at Heckfield.

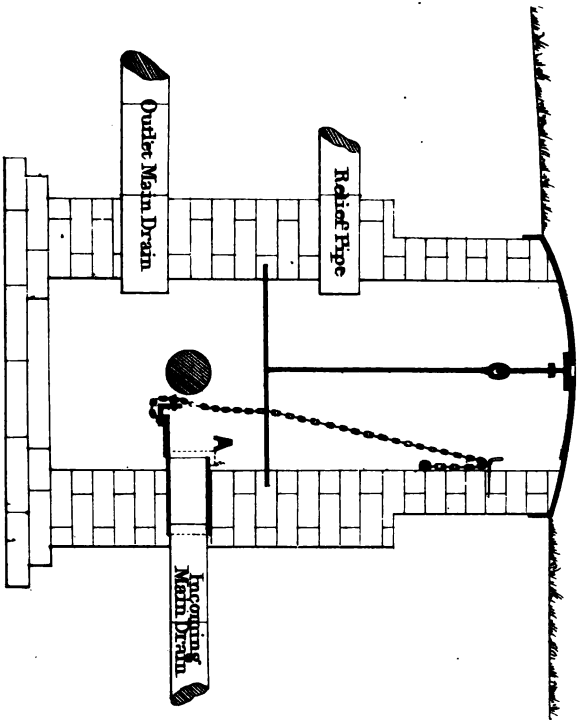
The annexed drawing shows the more important wells. They are made of brick or stone, with iron covers. It also shows the less important ones, made of sanitary pipes, placed on end, with iron covers also. The iron covers are made by Messrs. Stanley and Bower, of Peterborough.

When it is desirable to flush the main drains by letting in water from a stream hard by, a supply pipe is turned into that stream with a water-tight flap and fastening; and when it is desirable to flush the mains by holding back the water in the upper portion of the main, a flap put to the in-coming drain in the well (at A, for instance,) will answer every purpose.

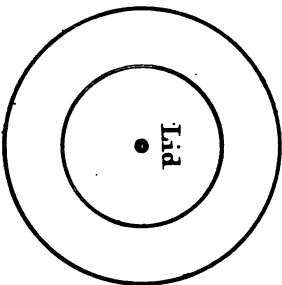
It is found that the use of this contrivance for flushing will get rid of the peroxide of iron about which so much complaint is made.

It is no doubt true that water could not issue from a drain unless there were a pressure of air upon the surface of the water, and that water could not descend through the soil to the drain unless it first displaced and was followed by an equal volume of air in the soil; but experience seems to sanction the opinion that air, admitted directly to the conduit of a long or a very flat main drain, will cause an increased rapidity of discharge, and as the truth of this may be ascertained at little cost by simply measuring the quantity of water discharged in a given space of time from main drains in the two conditions—before and after the admission of air—it is unnecessary to provoke discussion on a point which each person can so easily determine for himself. It may however be opportune to instance a case mentioned by Mr. George Beaumont, junr., of Bridgeford Hill, Nottinghamshire, in which an intermittent issue of a main was made constant by the admission of air: he says, "the drain delivered its water with a stopping action, similar to a pump spout; after air was admitted it discharged evenly and rapidly. The field was steep and the water plentiful." The presence of water in the inverted elbows of gas pipes, has been so often made manifest to us all, when we have

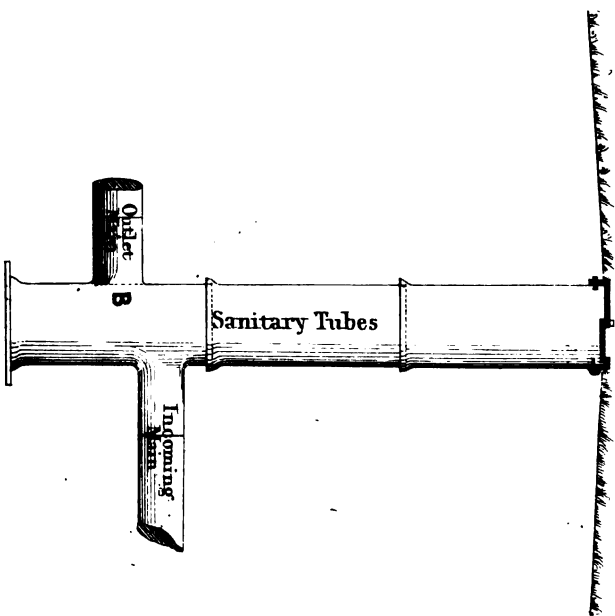
Large Well,
ManHole.
Section.



Plan of Cover.



Small Well.



Cover



been tantalised by the jumping of our gas jet, and the presence of air in syphons and water pipes has so often shown its power by impeding the flow of water, that we can appreciate the drainer's annoyance in cases like that mentioned by Mr. Beaumont. I am rather inclined to think that the intermittent effect referred to, proceeded more from a disregard of a true fall to the drain, and the omission of relief drains in the hollows, than from the want of air. But as the remedy was simple, I have thought proper to record it.*

Mr. Simon Hutchinson, of Grantham, who a few years back published a pamphlet, bearing the scientific title of "Drainage on Hydraulic and Pneumatic Principles," and recommended an air drain, connecting the upper end of the minor drains (which were to be three feet deep, "the best and most economical depth") writes me as follows—"I entertain the same views, only in a stronger degree, that I have held for several years past. I am not so entirely bound to a three feet drain as you appear to believe, *only I would have no drain of a less depth*. I never drain land without introducing an air drain."

The information collected, and my own observations and experience, do not support as a rule for *general* adoption Mr. Hutchinson's practice, although, as already intimated, instances are known where benefit has been derived by the use of air-shafts in main drains; and Mr. Hutchinson, and some other of my correspondents are prepared with cases where a circulation of air through the entire system of drains, by connecting them at the head, has caused an effect in the more rapid action of the drains.

It will be readily understood that as clay will always contract under the influence of a draught of air in consequence of the more rapid evaporation of moisture from its surface, one of the benefits of draining is thus very cheaply acquired, and for the denser clays it may possibly be a desirable thing to do, but in the porous soils it would appear that no advantage is gained by it. Many persons regard the admission of air to drains as an

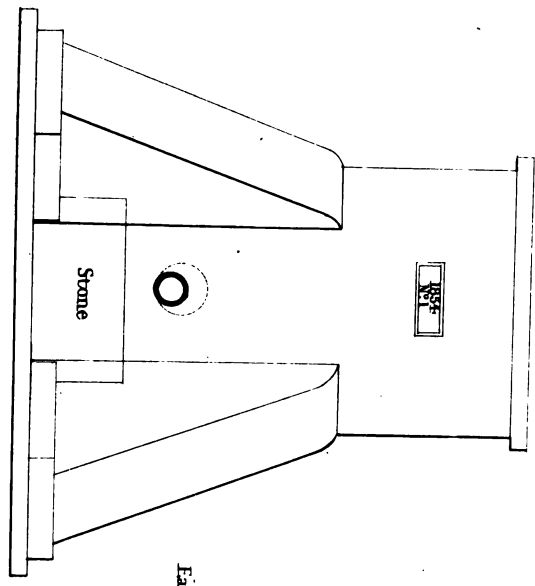
* This instance, though described by Mr. Beaumont, did not occur in any of the works executed under his management,—upon those, he states, air-vents have not been used.

impediment rather than an aid to drainage, but I have not yet seen that assertion proved.

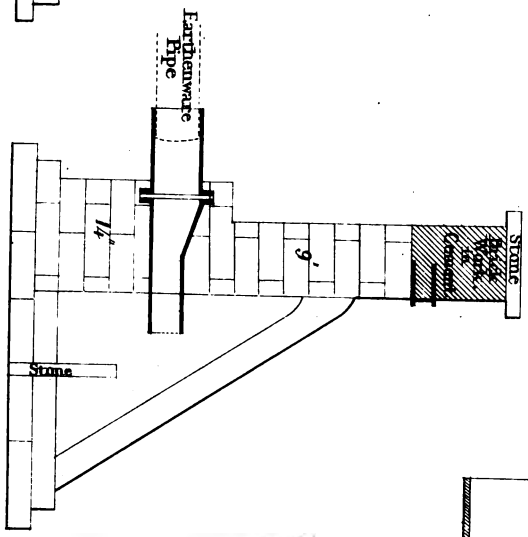
To satisfy myself on this point I tried the following experiment:—I got a box four feet long, three feet deep, and three feet wide, and put a strong plate of glass into one end of it, having cut a hole near the bottom of the glass to admit a one-and-a-half inch drain pipe. I filled the box with clay (after making it water-tight) to within four inches of the top, and continued the line of pipes, four in number, through the clay from the glass end to the other end of the box, and having pressed the clay closely together, and poured water into the box, I found, after the water had made its way through the clay into the pipes, and passed away, that the clay began to crack downwards from the surface, and upwards from the pipes, more readily than from the sides of the box against which moist soil was piled. When dry I traced the lines of cracks on the glass with a glazier's diamond, and again poured water into the box until the cracks closed, and nothing was seen of them. Again it dried, and I found by reference to the tracing on the glass, that the same cracks opened again. I then admitted air to the line of pipes by a large gimlet-hole through the box end, and I found by repeated and varied experiments, that not only did the water pass away more quickly with a current of air than without it, but the cracks radiating from the pipes increased in size and number. I am aware how imperfect this experiment will be deemed as a means of determining the question now under consideration; but when we remember how quickly a brickmaker will cover up his green bricks when he is surprised by a little freshness of wind, which he declares will "*fly his bricks to pieces*," and when we remember that the same maker, when he wants to mellow the clay he digs for making, is particularly careful in giving it "as much weather as he can," it does appear sound, that the more *clay* soils are aerated the better. I came to the conclusion that the admission of air into the drains did facilitate a change in the condition of the soil conducive to more rapid drainage, and to the amelioration of the soil.

Larger Outlets .

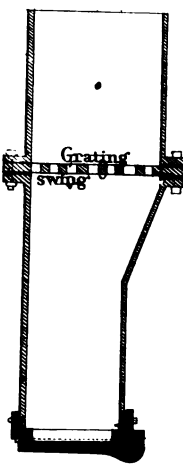
Elevation .



Section.



Outlet Pipe with Flap to prevent the influx of tidal and flood water .



Smaller Outlet .



Scale .



NOTE . Every outlet should bear a date and number .

Before dismissing this branch of the subject it will be opportune to remark that the proper selection of outlets, and a care for their preservation, is perhaps as essential to good and satisfactory work, as anything belonging to the art of draining. Too many outlets are objectionable on account of the labour of their maintenance; too few are objectionable because they can only exist where there are mains of excessive length. A limit of twenty acres to an outlet, resulting in an average of perhaps fourteen acres, will appear by the practices of the best drainers, to be about the proper thing. If a shilling an acre is reserved for fixing the outlets, which should be *iron pipes with swing gratings*,—in masonry,—very substantial work may be done. The iron outlet pipes I am putting up for the General Land Drainage Company are shown in the drawing opposite, and are made by Messrs. Stanley and Bower, of Peterborough.

Each outlet should be numbered by means of an iron plate with date as well as number, let into the masonry, and the numbers should be figured on a plan of the lands, having the site of every outlet, and the direction of the drains marked upon it. A specimen of such a plan is appended to this paper.*

The late Sir Robert Peel recommended this with much earnestness; and as a striking proof of the advantage of a proper record being kept of drainage works, I may mention that the General Land Drainage Company has just completed a contract in which is included the draining of a field, which, we found, had been drained not twenty years back at the same depth (five feet), as we were then draining it. But as there was no outfall ditch, until we commenced operations, of sufficient depth for the discharge of five-foot drains, and we were unable to discover the arrangement of those we came across, no use could be made of what had been done, and an outlay of many pounds was therefore entirely wasted. And I know of instances where draining executed *within the last five years* has become worthless

* In several drainages I am now superintending, I have undertaken to delineate, on plans provided by the landowners, the whole system of works at a charge of 6*d.* per acre, in addition to 5*s.* per acre for designing and conducting the works.

from a similar omission to maintain the outfalls, and to preserve a record of the mode of draining.

I submit that upon the fourth point, *direction of drains*, the results of the practice of the last few years have confirmed the principle of laying out the minor drains with the fall of the ground in the generality of circumstances—that the principle of carrying the drains across ridge and furrow may be departed from in certain soils without disparaging effect—and that let the direction of the drains be what they may, a constant and effective discharge can be secured and maintained in perpetuity, only by carefully designing, and by substantially securing the outlets, with due regard to arterial channels.

In the observations made under the four several heads now brought to a close, many minor practices, oftentimes called “systems,” have been introduced to your attention. I do not propose, therefore, to refer more particularly to them. In the same way, I am disposed to treat *the shallow drainage system*, which has been indirectly investigated in the course of my remarks, particularly as I see present Mr. Bullock Webster, the champion of that—I had almost said *departed*—“system,” and as I have so little to say in its favour.

Being desirous, however, of stating every fact which may support a fair discussion, I will communicate the little favourable evidence I have collected.

I find that Mr. J. E. Denison, of Ossington, drains “strong clays” two feet six inches deep; Mr. Milward, of Thurgarton Priory, still adheres to a depth varying from two to three feet; and Mr. Stephenson of Throckley, to three feet;—and these are undoubtedly high authorities.

But we must not forget that very nearly the last words Smith of Deanston wrote on the subject of Draining were these:—“I do not so much object to greater depths than three feet, as I do to greater distances in all soils;” and, although this is a sort of negative

concurrence in increased depth, we are bound to believe that the founder of the shallow system saw reason to modify his first views.

The Combined Deep and Shallow, or Lord Wharnccliffe's System.

—This system was discussed and described by Lord Wharnccliffe in the Journal of the Royal Agricultural Society of England (1851), and may be described as a compromise of the two principles of *depth* and *direction*, by the mixture of drains two feet deep, with drains four feet deep, and the introduction of short minor drains across the fall in connection with longer minor drains following the fall. It is thus lucidly described by his lordship :—

“Now, if the evidence we have had of similar operations in other quarters can be trusted, there is nothing in the circumstances of the case to account satisfactorily for failure. Clays as close and deep are positively asserted to have yielded all that could be desired to simple four-feet drains.

“It strikes me forcibly that the true solution of this question probably lies in an agency of which too little account has hitherto been taken by our otherwise able leaders and instructors in the art. Their attention has been exercised perseveringly upon diversities of soil, and we must now bestow more of it upon those of climate. Its differences within these islands are confessedly great; let us inquire how they are likely to affect our results.

“In order to secure the full effect of thorough drainage in clays, it is necessary that there should be not only well-laid conduits for the water which reaches them, but also subsidiary passages opened through the substance of the close subsoil, by means of atmospheric heat and the contraction which ensues from it. The cracks and fissures which result from this action are reckoned upon as a certain and essential part of the process.

“To give efficiency, therefore, to a system of deep drains beneath a stiff clay, these natural channels are required. To produce them, there must be a continued action of heat and evaporation. If we draw off effectually and constantly the bottom water from beneath the clay, and from its substance as far as it admits of percolation, and by some other means provide a vent for the upper water, which needs no more than this facility to run freely, there seems good reason to suppose that the object may be completely attained, and that we shall remove the moisture from both portions as effectually as its quantity and the substance will permit. Acting upon this view, then, after due consideration, I determined to combine with the fundamental four-feet drains a system of auxiliary ones of much less depth, which should do their work above, and contribute their share to the wholesome discharge, while the under current from their more subterranean neighbours should be steadily performing their more difficult duty.

“I accomplished this by placing my four-feet drains at a distance of from eighteen to twenty yards apart, and then leading others into them, sunk only

to about two feet beneath the surface (which appeared upon consideration to be sufficiently below any conceivable depth of cultivation), and laying these at a distance from each other of eight yards. These latter are laid at an acute angle with the main drains, and at their mouths are either gradually sloped downwards to the lower level, or have a few loose stones placed in the small intervals between the two, sufficient to ensure the perpendicular descent of the upper stream through that space, which can never exceed, or indeed, strictly, equal the additional two feet."

I have already anticipated the motive of Lord Wharnccliffe in the digression into which we were led when considering the influence of cost in regulating the questions of depth and distance, under circumstances suggested by the late Sir Robert Peel, through the pages of the "Quarterly Review."

Lord Wharnccliffe starts with the arbitrary view that 5*l.* is the maximum amount of money that should be expended in the drainage of an acre of land, and in doing so, places himself just in that exceptional position conceived by Sir Robert; with this difference only, that while the latter assumed 4*l.* an acre as the limited amount to be expended, Lord Wharnccliffe takes his stand at 5*l.* per acre, with these words, "In my district I have always thought that if I could bring the expense within 5*l.* an acre, I might be fairly satisfied, and, I believe, my tenants too."

The value of Lord Wharnccliffe's suggestions, on his lordship's own showing, can only be entertained by admitting the plea of expediency to outweigh the influence of principles which he acknowledges to be correct, in these words: "There are few instances in which I would willingly stop short of a good four feet," and "the dominant direction should be that of the slope to be drained." Now, to test the abstract question whether, in dealing with drainage, we should sacrifice principle to expediency, we should call to mind the obligations to permanency and improved value imposed by the Drainage Loan Acts; for, in cases where landowners do not pledge their successors to contribute to the outlay, it matters very little to any one but themselves in what way they gratify their views of economy.

If the Inclosure Commissioners, acting as the protectors of reversionary interests, will, contrary to our belief, permit of a

less minimum depth than four feet where there is ample capability of outfall (as was stated publicly by Mr. Wren Hoskyns at Lincoln to be the case), it remains therefore only to be considered—having made a limit of cost the measure of our proceedings—how we shall spend a prescribed amount to the best advantage.*

No one will contradict Lord Wharncliffe in his declaration, that his lands are improved by the method of draining he has adopted, simply because it would be impossible to deny that any drain, even two feet deep, can be put into land without doing some good; but the extent of improvement his lordship congratulates himself upon, and which I learn from several is manifest to every one, is, doubtless, to be ascribed in a much greater degree to the influence of the four feet drains than to the two feet drains; for it is impossible to reconcile with any laws of hydraulics, engineering, or economy, the union of the two depths in one system. The drains of the greater depth must detract from the utility of those at the less. The two directions cannot both be right. The numerous junctions are liable to constant disarrangement. It would appear, that, by adopting an uniform depth of three feet six inches, which, although not so good a depth as four feet, is a respectable depth, at intervals of twenty-five feet, a much more *permanent* drainage could have been secured for the 5*l.* an acre, than by any method of which a depth of two feet is an element, if we are to look forward to deep cultivation. The following are the prices at which I am now getting four feet drainage done in some few places, and at which, in 1850 and 1851, it was done pretty generally throughout the country:—

	£	s.	d.
Labour, 6½ <i>d.</i> per rod of 5½ yards	2	17	0
Pipes, 1½ in. and 2 in., at 17 <i>s.</i> per 1000, for minor drains .	1	11	4
Pipe-laying, outlets, and extras	0	11	8
	£5	0	0†

* To determine this question, it will be necessary to study all the details set forth in Table I.

† Mr. Parkes, in his "Fallacies of Land Drainage Exposed," would appear to consider that four-feet drainage at the same intervals (twenty-five feet)

I have omitted the cost of haulage, because, it appears by Lord Wharncliffe's statement, that this work was done by the tenants.

Many landowners seem to have adopted the above depth and width in stiff clays, and Mr. Curtis Hayward, speaking of the *lias*—a much more difficult clay to deal with than that at Wharncliffe—says, "I prefer eight yards, at three feet six inches depth, to any deeper drains at wider intervals."

Convinced that no one who reflects upon the subject, and puts Lord Wharncliffe's combined system to the test of true scientific principles, will ever adopt the method as one upon which to start the drainage of an estate, we must now look at it in the manner in which Lord Fortescue has applied it—*i.e.*, to remedy the *too wide* system.

I will here introduce a statement with which I have been favoured by Lord Fortescue. It is addressed to his lordship by his son, Lord Ebrington, who, we all know, has taken considerable interest in the subject of drainage generally, though more in respect of the sanatory improvement of towns than perhaps in connection with land.

"Sept. 18th, 1853.

"I have been over a number of fields drained under Mr. Parkes's superintendence almost exclusively with drains four feet deep, and forty feet apart. In some, especially of the grass land, with only a moderately retentive subsoil, the effect has been excellent, the rushes have disappeared, and the herbage has improved in quality and increased in quantity; but many of the arable fields, where the subsoil is a stiff clay, show marks upon their surface of the long retention of water on or near it. The crops in some of these (near the new farm) have been completely destroyed by the wet; others, intended for roots, are still lying waste, owing to the impossibility of getting upon them (to work them) for more than five weeks together, in consequence of the heavy rains in June and July. A fortnight of dry weather has scarcely sufficed, after heavy rain this summer, to dry them enough for the purpose. We also examined together some of my fields (similarly drained by Mr. Parkes). We both looked at them from a distance, and walked over them in detail. In the clayey land (like that above mentioned), narrow strips of good roots (mangold and carrots)

could be executed for less than 4*l.* 10*s.*; but I hesitate to adopt such figures, because they are based on an assumption that *suitable* pipes can be purchased for 13*s.* per thousand!

between wide intervals of stunted or dead plants ; though all were put in with the same care and highly manured, and though the land is not in itself bad, having produced above fifty bushels of oats last year. The effect of the drains is in this case the more conspicuous, from the drills, though equally taken up and down the slope, happening to run a little slanting across the drains, so that the breadth of better growth over and near the drains, though certainly on an average not above ten feet in all, is composed of several different drills in succession for a part of their length. The appearance presented by the turnips at May's Leary, hard by mine, is exactly the same, but, from the greater poverty of the ground, the stripes of better roots are proportionably narrower. After reading the account of Lord Wharncliffe's system, and of the success stated by his steward and tenants, and by an impartial and enlightened friend, Mr. Graburn, to have attended it after a full trial, I determined upon trying its principle last winter, but I did not carry it out to its fullest extent ; for, instead of putting two two-feet drains in the forty-feet interval between each of my four-feet ones, I only put one, and I brought that straight down the slope (parallel to the original four-feet ones) into a separate drain, instead of conducting it, herring-bone fashion, into the nearest four-feet drain, as Lord Wharncliffe recommends.

"The land thus treated presented a marked contrast to the other land ; the strips of flourishing roots being not only broader than those above described, but also much more flourishing ; while the less flourishing roots in the still unduly wide intervals had evidently suffered much less from the wet. I had in the spring ridden with the bailiff over nearly all the same ground as now, when, viewing yours from the opposite hill after some weeks of dry weather, the surface could be seen then distinctly marked with long, narrow, light-brown stripes in the lines of the drains, running down between dark-brown intervals of wet ground, which, when we got upon them, were then still soft, and unfit for working. We were then struck with the contrast presented by the uniform colour and appearance at a distance of the whole of that which I had inter-drained as I have mentioned above, and with its firmness and dryness under foot. At that time we found the four-feet drains discharging freely, while the two-feet ones were hardly running at all. On subsequent visits to both, I found the two-feet ones quite dry, after long-continued fine weather, and the others comparatively unaffected ; but on Wednesday last, after a heavy rain on Monday night, we found the two-feet main from about three acres (though crossing the four-feet drain in many places, and therefore leaking a little into them) was discharging a volume of water larger, if anything, than the four-feet main from about fifteen acres ; and I observed the same thing continued on the two following days.

"In your experimental field near the poor-houses (originally drained by Mr. Parkes like the rest), we found the portion left as it was, decidedly wet : but the rest in a tolerably uniform and satisfactory state throughout the different portions which were treated, as you know—the first with one two-feet drain, the second with two two-feet drains, the third with one three-feet drain, and the fourth with two three-feet drains between each of the original four-

feet drains. We agreed, however, that there was a slight but perceptible superiority in the double-drained over the single-drained intervals, though none distinguishable between those drained with the two and three-foot drains. The shallow-drain main in this field seemed to be discharging very little—less indeed from the hole at its mouth than from part only of the brick-cesspit placed about half way down it for the purpose of inspection; but this circumstance is easily accounted for by the fact of the mains having to pass over several four-foot drains in its course. The four-foot main was discharging very freely.

"I have looked at the Meadow Park drained about seven years ago with drains made of broken stones, thirty inches deep, and I think twelve feet apart. The land appears drier than that of similar quality drained by Parkes, and the bailiff assures me it has become fit for working after rain much sooner, but it seems to require a few deeper drains to lower the general level at which water stands below its surface, as much as the latter appears to require some intermediate drains to accelerate the removal of the water; which in this wet climate is throughout much of the year replaced by fresh rain before the former rain has had time to make its way such a distance through the earth as to Parkes's drains, four feet deep and forty feet apart. It cannot now be said, as I know it has before, that the wetness of your land, in spite of Mr. Parkes's drainage, is the result of poaching by cattle, or injudicious working in wet weather; for the greater part of what I have described has not been entered upon by horse or man, beast or sheep, during the wet weather. Indeed, much of it has been left as yet absolutely untouched. Under these circumstances, your steward, your bailiff and I, have come to the conclusion that that part of your land which is still wet requires further draining; that part of it which is intended to remain arable, with drains at distances of about twelve, and not exceeding fifteen feet. The only point on which we feel unable to pronounce confidently is as to the proper depth of the intermediate drains. At the same time, as we have seen much benefit, and heard from Yorkshire of much more, resulting from two-foot drains between the four-foot ones, and as the cost of this depth is obviously less than at a greater, we recommend, for the present, that what is done should be done at two feet. Ridging up the land we think will be necessary besides, for some time after this has been done, judging from the proof we have of water standing upon the very backs of four-foot drains, and very near, if not actually, upon two-foot drains. As to the grass land still wet, we think that it will not require quite such close additional draining; probably one intermediate drain, perhaps of greater depth (say three feet), would suffice.

"With regard to this experimental field, your steward states that he went about a month since to look at its drains, after some heavy showers. The two-foot drain he found running very little, while the four-foot drain was discharging a fair average quantity. A shower then came on, and he went away to take shelter for about ten minutes. On returning, he found the two-foot drain had increased its discharge to about three times its previous amount, while the four-foot showed only a very slight, though just perceptible, increase.

"I may here mention, that the people on our two farms say that they constantly find the two-feet drains dry after continuous dry weather, but that after heavy rains they seem to discharge much more water in proportion to their length than the four-feet drains, which seem to be comparatively little influenced by change of weather."

Having inserted this communication in full, it is necessary to explain that my object in doing so, has been to afford those who are interested in the discovery of truth, the benefit of those details which Lord Ebrington has so fully expressed. I need hardly say there was every probability of insufficient drainage at forty feet intervals, in a situation where the climate is so constantly humid, as it is known to be at Castle-hill, where the average annual fall of rain approaches fifty inches, and where the average number of wet days in the year is 191 days; but, at the same time, I must disclaim concurrence in the operations adopted and still recommended by Lord Ebrington as a remedy.

It would almost appear that there are defects in construction and details, for which Mr. Parkes could not be held responsible; operating adversely to his intentions. Inch-pipes for minor drains, and a long draught for main-drains, are means of drainage very easily abused by inferior workmen; but as I have not seen the work, I venture upon no other opinion than that I have expressed with respect to width.

It will be remarked that the fact recorded by Lord Ebrington, of the shallow drains running before, and more copiously than the deeper ones, although within the limits of their influence, is directly contradictory to the observations of Mr. Parkes, in his Newcastle lecture, in which he states—

"The remark made by Mr. Andrew Thompson, as to the deep drains giving issue to rain-water, in land under precisely similar circumstances, before shallow drains, agrees with the observation of a great number of farmers whose land has been so drained; and it would be difficult to cite a more apposite proof, I think, of the superior condition into which the mass of the soil is brought by deep drainage. That this should occur in a field where shallow drains exist in the neighbourhood of deeper drains, and within their influence, would be naturally expected, as the water keeps on descending below the level of the higher and until it reaches the level of the lower vents, where it meets with free water, and then begins to travel horizontally to the drain. The

reason, however, why the deeper drain in one field should begin to discharge before another and a shallower drain in another field, or in a very distant part of the same field, having precisely similar soil, is not quite so obvious. I have this day received from a tenant-farmer in Yorkshire an account of an observation of his, that a four-feet drain began to run five minutes earlier after rain than another drain sixteen inches deep at a distance, but in the same field. Some experiments are being made which may elucidate this action, which tells so favourably for the deeper drainage."

The Keythorpe, or Lord Berners' System, has been described by Mr. Joshua Trimmer, the eminent geologist, to be a system of draining by channels transverse to certain ridges and furrows found to exist between soil and subsoil—or to use the words of Mr. Trimmer, "between the warp drift and the erratic tertiaries of the older strata on which the warp drift rests"—with a view to intercept the water which finds its way through the porous warp-drift into the furrows. On the authority therefore of Mr. Trimmer, the Keythorpe system may be accepted as one based upon geological data.

The characteristics of Lord Berners' system are—

1st. The drains are neither equidistant nor of regular depth, their position and depth being determined by the shape of the subterranean undulations and the depth of the furrows. The intervals between drains varying in the same field from fourteen to fifty-nine feet, and the depths, apparently from eighteen inches to four feet.

2nd. The drains cross the line of greatest descent (obliquely) in order to intercept the water flowing down the furrows referred to, "which are generally found," Mr. Trimmer says, "on land with a considerable fall and run, in most cases in the direction of the fall."

3rd. The efficacy of the drainage depends upon a precise knowledge of the breadth and depth of the ridges and furrows.

Without presuming for a moment to deny the existence of the conditions of soil and subsoil described as prevailing at Keythorpe, I would earnestly suggest to the members of this club, and to agriculturists generally, the advantage of investigating the principles set forth by Mr. Trimmer, that surface soils are generally distributed on a ridge and furrow subsoil in steep lands, and that the undulations are of such continuity of form as to allow of the establishment of a "system" of operations.

I am bound to admit, that having searched with a sincere desire to find those signs which would support Mr. Trimmer's views, I have found all manner of contortions in the distribution of soil upon subsoils, from potholes many yards deep to a covering no thicker than a pancake; and where furrows have existed of any length at all, I have found them to run in all directions, contradictory to any systematic arrangement of drains. Still this omission to detect the principles insisted upon by Mr. Trimmer, arises no doubt from geological incapacity on my part; and as we have already discovered so many errors in past practice, it is to be hoped that Mr. Trimmer's intimate knowledge of surface geology may yet lead practical men to many valuable truths hitherto unappreciated only because they are unknown.

At present the objections to the Keythorpe Drainage may be reduced to—

1st. Insufficiency of depth, inasmuch as one-tenth of the drains are only one foot and a half deep; and

2nd. A disregard of the laws of gravitation, by the adoption of drains laid (obliquely) across the fall.

3rd. The absence of tangible data for setting out the work.

It is little to the purpose to compare Lord Berners' drainage at depths varying from one foot and a half to four feet, with the parallel system, uniformly four feet deep. The object aimed at, and the result which would follow, would be very different in each case. Lord Berners may have effectually got rid of injurious water, but his lordship has evidently disregarded the value of water as a friend to the soil, and the advantages of deep cultivation.

And as it is very much like going back a century, to entertain any system of which drains eighteen inches deep form a part, and as I know my friend Mr. Trimmer is the last man to retrograde in any scientific pursuit, I would avoid connecting his name with the Keythorpe system otherwise than as a narrator of that system.

Mr. Trimmer's object, as I understand it, in taking this work upon himself, was not to prove that shallow and cross draining

was right, but that a knowledge of the distribution of surface soils may be serviceable in drainage operations. No one can deny the advantage of this knowledge, if it can be made practically available; but at the same time that this is conceded, it is impossible that any one who believes in the principles of deep drainage with the fall of the land, can adopt the system followed at Keythorpe.

Spring Drainage.—It will have been observed, that when taking the various systems of drainage in the order of their organisation, spring drainage was passed by with a slight allusion to Elkington.

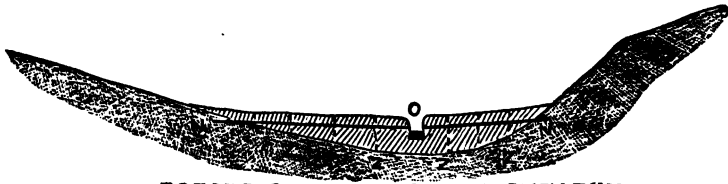
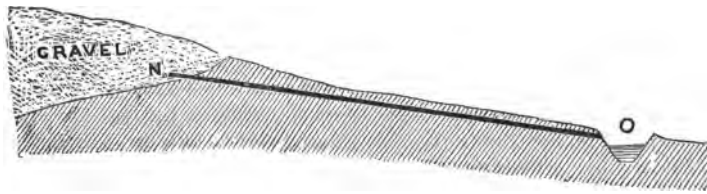
The reason for so doing will be apparent when reference is made to the text of this discussion, the systems to be considered being those only which have been in practice within the last few years; and as I am not aware of any method of treating springs which is recognised as a "system," besides that of Elkington, and as it does not appear that any person now will undertake to do what Elkington did sixty years back, it would have been inopportune to have dwelt upon the point at the commencement of this paper.

But it would not be right to dismiss from our attention altogether this most important branch of the subject, particularly as a very important and cheap mode of dealing with springs and "the water of pressure," as it has been before called, is gradually getting into practice in spite of the doctrine, that all waters affecting land may be divided into *top* and *bottom*.

The late Mr. Gisborne very aptly described the only certain method of eradicating a spring; and it is a pity that he ever allowed the "top and bottom water theory" to distract attention from those telling words by which he explained a process daily becoming more and more recognised and approved. His words are these: "Nature shows you the weakest place—you should assist her. *Hit her straight in the eye*, is as good a maxim in draining as in pugilism." And so it is, as every practical man unfettered by rule will tell you, springs which burst out at

the hill side surface, or the water of pressure which oozes by diffused means to the surface, are alike subdued by *deep drains going direct to the seat of the evil*. Draining men call them "headers," because they deepen as they rise the hill, and because they undermine rather than meet the out-pressing water. Boring in the course of these drains (z z z) is resorted to with good effect, and with economy, where clay overlaps the water-bearing stratum. As soon as the boring tells upon the water it is intended to lower, further cutting is stopped.

These "headers" are shown by the line of drains from o to N.



POROUS CHALK OR SANDY STRATUM

The following extract from the "Quarterly Review" explains shortly and clearly one of Elkington's methods of tapping springs. It will serve to illustrate his system, which embraced the Artesian mode of boring :—

"Perhaps in Agricultural Britain no formation is more common than moderate elevations of pervious material, such as chalk, gravel, and imperfect stone or rock of various kinds, resting upon more horizontal beds of clay or other material less pervious than themselves, and at their inferior edge overlapped by it."

"From a to t is the overlap, which is in fact a dam holding up the water in the gravel. In this dam there is a weak place at s, through which water issues permanently (a superficial spring), and runs over the surface from s to o. This issue has a tendency to lower the water in the gravel to the line m m. But when continued rains overpower this issue, the water in the gravel rises to the

"The highest part of the syphon is twenty-one feet above the present-surface of the loch, and the longest limb of the syphon is ten feet under the level of the water, giving ten feet of fall.

"The discharge of the water at the present time is about 200 gallons per minute, but at first, when the loch was at its original height, and the fall greater, of course the discharge was much more.

"The main part of the syphon consists of cast-iron pipes five-eighths of an inch thick, with spigot and faucet joints very carefully joined and made air-tight with lead. The contract expense of the iron pipe laid, when complete, was 7s. 6d. per yard.

"The loch being shallow at the edges, and full of sludge, it was found difficult to connect the syphon with the deep water. This difficulty was overcome by building a well of timber of such height that when sunk in the deepest part of the loch the top would be above the water. After connecting to this well above eighty yards of six-and-a-half-inch lead pipe, it was floated out into the deep water, the lead pipe extending to the land, when the well was sunk by stones, and the lead pipe being afterwards carefully joined to the cast-iron syphon on the dry land, the syphon was complete and air-tight.

"The syphon was filled by a very simple contrivance. An hydraulic valve was fixed to the end of the syphon, within the wooden well sunk in the deep part of the loch, and another was fixed at the lower end, and water was then introduced at the summit level by a supply brought in a tile-drain from another lake. The water was let in by a two-inch cock at the summit, while the air was allowed to escape by an inch-and-a-quarter air-cock alongside of the other.

"The syphon was thus filled in about two hours, and the cocks at the summit being closed, and the valves at both ends opened at the same instant, the water passed rapidly through the syphon, which seemed to work quite successfully. It was found, however, after working thirty hours, that air had been gradually lodging near the summit, and finally cut off the connection and stopped the discharge. This was calculated upon, and, to overcome this evil, two air-pumps three inches diameter, ten-inch strokes, and twenty strokes per minute, were attached to draw off the air as it lodged. A small water-wheel to work these pumps was placed at the low end of the syphon, to be driven by the water as discharged. The pumps are connected with the syphon by an inch-and-a-quarter lead pipe, conducted to near the summit level at a point where, on an experimental glass model, the air seemed to lodge, and this contrivance has been so far successful. The wheel has gone on working night and day, the pumps drawing air when there is any, or, if not, water, till the loch is now lowered nine feet under its former level. It might be drawn lower still, but much difficulty has arisen from the sludge pressing in towards the mouth of the syphon, and from the whole bottom of the loch consisting of a great depth of an impalpable sludge, which must take some time to consolidate and become workable."

Mr. George Guthrie, his lordship's agent, thus writes to me on the 2nd instant (2nd December, 1854).

"The syphon seems quite to have answered the purpose intended, and is now working without interruption, giving the same discharge of water as at starting. The pumps have required very little attention farther than regular oiling. The syphon might draw off water to a greater depth than nine or ten feet, but the sludge which was on the sides of the loch has fallen in round the wooden well in the centre, and prevents us drawing much above nine feet. I contemplate in another year to sink a well on the hard ground at the side of the loch, of greater depth than nine feet, connecting the syphon with that well, and conducting the drainage and loch water into it, to gain eleven or twelve feet for our drainage.

"On the whole, the syphon drainage has answered our purpose, in avoiding a most expensive cut (estimated at 2000*l.*) through quicksands. That cut would have required to have been above forty feet deep at some places. But, of course, I would not recommend the syphon for general use, unless under somewhat similar circumstances, where it would be to save a very expensive cut through either quicksand or rock.

"I am, your faithful servant,

"GEORGE GUTHRIE."

Having said thus much upon the systems of drainage which have prevailed while the agricultural interest have enjoyed the peculiar and exclusive benefit of borrowing from the public purse, it may not be out of place to refer to the means which will remain at command of owners of entailed estates for the continuance of the work to which such a stimulus has been given, now that we must resort to the more English and more independent medium—*private capital*. The relevancy of this consideration to systematic drainage will appear when we recur to the past and present influence of the Government Inspectors on the drainage done, and doing, by aid of the public money; and it is not too much to expect, that when the competition of private enterprise, and the application of private capital, are brought to bear upon the economy of drainage works, an influence arising from the source whence the money is obtained, will be more or less experienced.

It has been stated that the money already expended under the Public Drainage Acts is 2,239,157*l.* 12*s.* 10*d.* The total amount at the disposal of the Commissioners is 4,000,000*l.*; there is therefore rather more than one million and three quarters yet

to expend. The amount of money, however, applied for, and bespoken, under the same Acts, is * 3,951,150*l.*, which, it will be seen, so closely approaches the sum in the hands of the Commissioners, that there is little hope for those who made no application at all, except in particular counties, in which less activity in improvement has been evinced than in others.

The average cost per acre of *effective* drainage being known to exceed 5*l.*, it follows that the total quantity of land that can be drained by aid of the Government funds will be less than 800,000 acres,—not half the extent of the single county of Lincoln; and when we reflect that the total surface of Great Britain is 56,352,000 acres,† of which 43,958,000 acres are cultivated land and waste land *capable of improvement*,—that at least one half of this quantity, or 22,000,000 acres, are yet capable of improvement *by drainage*, and that 15,000,000 acres of this 22,000,000 acres, are said to belong to owners having but limited interests in their

* It is well known that our enterprising Scotch friends have applied for a larger share of the sum at command than the landowners of England and Wales together, as the following amounts will show :—

England,	957	applicants for	£1,706,584
Wales	53	„	107,199
Scotland	892	„	2,137,367
Total			3,951,150

Since the above paragraph was written (November, 1854), the whole of the four millions has been applied for.—December 22nd, 1854.

†	Total Content.	Cultivated Land.	Uncultivated and Waste capable of Improvement.
England	32,247,680	25,632,000	3,454,000
Wales	4,752,000	3,127,000	530,000
Scotland	19,352,320	5,265,000	5,950,000
TOTAL	56,352,000	34,024,000	9,934,000

Cultivated Land	34,024,000
Improvable Land	43,958,000
Remainder barren	12,394,000
Total	56,352,000

estates, upon which the equity and expediency of applying borrowed capital has been legally acknowledged, it becomes a matter of much moment that improving landowners should know whence the funds are in future to come, and what influence the source of supply is to have on the *modus operandi*.

Owners of settled properties have the choice of several means of charging the cost of draining upon the inheritance, and through each medium they can either borrow the money to be expended, or they can apply their own private funds to the object, and take a rent-charge on their estates for the repayment, in which latter instance they will retain personal power over the disposal of money expended, and can leave to whom they please the rent-charge payable by their successor.

The means referred to are the *Private Money's Drainage Act* (12 & 13 Vict. cap. c.), limited to draining only,

The West of England or South-west Land Draining Company's Act (11 & 12 Vict. cap. cxlii.), for the purposes of

Draining,
Irrigation and warping,
Embanking, reclaiming, and enclosing,
Road making,

The General Land Drainage and Improvement Company's Act (12 & 13 Vict. cap. xci.), for the purposes of

Draining,
Irrigating and warping,
Embanking, reclaiming, and enclosing,
Road-making,
Erecting farm buildings,

And the Lands Improvement Company's Act (16 & 17 Vict. cap. cliv.), for the purposes of

Draining,
Irrigating and warping,
Embanking, reclaiming, and enclosing,

Clearing lands,
Erecting farm-buildings,
Road-making, and planting for shelter.

The terms of years over which these several Acts of Parliament enable landowners to extend the repayment by equal annual instalments of the amount expended, as well as the annual amount by which the repayment is effected, may be thus compared :—

	Period over which the Repayment may extend.	Proportion of Amount expended to be Charged.	Annual Instalment,* or Rent-charge.
<i>Private Moneys Drainage Act.</i> Draining	22 years.	All.	£ s. d. From 6 <i>l.</i> 10 <i>s.</i> 1 <i>d.</i> to 7 <i>l.</i> 10 <i>s.</i> 11 <i>d.</i> Present charge, 7 <i>l.</i> 5 <i>s.</i> 1 <i>d.</i>
<i>West of England Company's Act.</i> Draining Irrigation and Warping Embanking, Reclaiming, and Enclosing Road-making	In perpetuity.	All.	According to the prevail- ing value of money. Pre- sent value, 4½ to 5 per cent.
<i>General Land Drainage and Improvement Company's Act.</i> Draining Irrigation and Warping Embanking, Reclaiming, and Enclosing Road-making Farm-buildings	50 years. 31 years.	All. All.	5 2 10 6 3 2
<i>The Lands Improvement Com- pany's Act.</i> Draining Irrigation and Warping Embanking, Reclaiming, and Enclosing Clearing Lands Farm-buildings Road-making Planting for Shelter	25 years.	All. ¾ of Cost. ½ of Cost.	From £6 10 8 minimum to £7 11 0 maximum. £6 15 0 is the present charge.

* The information conveyed by this column is perhaps all that concerns the

Under either of these acts a landowner may charge his estate; but it is by arrangement with either of the moneyed companies that he can borrow capital for the work, unless he calls to his aid a third party (a banker or an insurance office, for instance), and then he can put in motion the Private Moneys Drainage Act, and avoid the commission charged by the companies.

From experience, however, already gained in the working of these several acts, it is found that the legal expenses attending the Private Moneys Act, and the higher rate of interest required by private bankers on single transactions of the kind, together with the risk and responsibility attached to the works, and of charging the estate, far outbalances the commission required by the trading companies, who are enabled by extensive dealings to effect the monetary arrangements much more easily and cheaply than an individual landowner, and without any examination of titles, and notice to mortgagees, except in the case of the Lands' Improvement Company.

If the landowner desire only to charge his estate with moneys he himself may expend, the process will be found very easy and very cheap, and he can select whichever company will do it with the least trouble and cost. About three per cent. will cover the latter, and it can be spread, like the cost of the work, over any period not exceeding fifty years. Considerable advantage, how-

tenant farmer. The less rate of instalment paid by the landlord, the greater will be the probability of effective work for a given rent charge; *i. e.*, a larger outlay will be repaid by the same annual instalment. Let us suppose, for instance, that a tenant concurs with his landlord that if certain lands were drained those lands would bear an advance of rent of 6*s.* 6*d.* per acre. Suppose, moreover, that they would be effectually drained, at eight yards apart, at a cost of 6*l.* 4*s.* 8*d.* per acre (see Table I.), and that they would *not* be effectually drained at ten yards apart, at a cost of 5*l.* 1*s.* 5*d.* per acre. Both landlord and tenant would prefer the larger outlay, but the former hesitates because he fears an annual loss during the period of repayment. By extending that period to fifty years, he can repay the 6*l.* 4*s.* 8*d.* by an annual charge of 6*s.* 4*d.*, affording the landlord a profit of 2*d.* per acre per annum; whereas, if it were limited to half that period, the annual charge would be 8*s.* 0½*d.*, whereby the annual loss to the landlord would be 1*s.* 6¾*d.* (See Table II.)

ever, is gained by a landowner who desires to bequeath a rent-charge to a younger child, by lengthening the duration of the charge to the longest admissible period.

If he desires to borrow of a company the amount required for works executed by his own agency, he will find equal facilities given him by two at least of the companies, and the charge for commission will vary from five to six-and-a-half per cent., including all expenses.

And if a landowner desire, not only to borrow capital, but to gain the use of a company's experienced staff of workmen, there are many advantages in this union of capital and skill, which will present themselves to those who may desire to be relieved of responsibility, and to avoid the advance of capital for the execution of the works. The Commission for superintending drainage works, for providing working staff, for finding capital, and keeping accounts varies from 10*s.* 6*d.* to 12*s.* 6*d.* per acre. The Commission for Building and other Improvements will vary according to circumstances, and is made in the shape of a per centage, which merges into the cost of the work, and is charged upon the inheritance. But one of the greatest advantages in the employment of a company with capital at command, is that large contracts embracing different descriptions of works—parallel drainage on uniform soils, and spring or occasional drainage—may proceed without precipitation. Doubtful portions may rest at stages, while the contract is in progress, for the development of effect and the observation of those who conduct the works. By such a course all unnecessary outlay may be avoided. None but those drains that are indubitably essential need be put in during the first season. If after one year's observation, particular drains are found to be requisite to perfect the work, they can be added without waste of a single rod, whereas it too often happens that a desire to be repaid money expended, and the necessity of getting the work passed as perfect by an inspector, lead to an unnecessary multiplication of drains, and a waste of capital. Those landowners are few who can afford to let 3000*l.* or 4000*l.*, rest a year compared with those who desire re-payment of every

500*l.*, directly it is expended. But the advantages of private companies do not stop here.

It is the duty as it is the interest of each competing company to take advantage of all practical improvements and the growing knowledge of the day, and to resist as much as possible the restraints of prejudice, while they refrain from the too hasty adoption of dogmatical theories. It is their duty to employ an experienced staff, if they are to have weight as operative bodies ; and speaking as an officer of one company, I feel that my retention of office depends upon the fidelity with which these public obligations are supported.

Lord Portman, while leading the opposition to perhaps the most useful drainage measure ever introduced into Parliament, especially signalised himself in heaping opprobrium upon *private Drainage Companies*, but that noble patron of agriculture has not given any reason for confounding the common denunciation of railways and other commercial companies, with the case of Incorporated Drainage Companies, *whose powers can only be brought into action by the instrumentality and for the immediate benefit of landowners themselves.*

His lordship will do well perhaps to remember that the competition of railway companies has brought the railway system to the excellence in which we find it, and it may fairly be asked if that excellence would have been as early arrived at, if the advancement of the system had depended only on the official progress of railway inspectors' management.

Comparisons on this point are familiarly drawn from the management of the Woods and Forests, and the history of ship-building by the Admiralty ; and it is asked whether the Government system of managing woodland, and of building ships, has produced more profitable results than are to be found on private estates or in the private dockyards of Glasgow, Aberdeen, and Greenwich ?

But I almost hesitate at even quoting these comparisons, lest I should appear to undervalue the important services of the drainage inspectors, and the higher presiding intelligence by

whom the appointments are made, and the investigations so vigilantly directed ; all that I desire to convey is, that the agricultural community at large must be benefited by the additional powers and resources, as well as the natural conflict of mind and experience, which competing companies may bring to bear on the subject.

I should perhaps be misleading the public, did I not shortly explain that the West of England Drainage Company is stated to be an *operative* company only. The General Land Drainage and Improvement Company is not only an operative company, but it provides money to landowners who have executed approved works.

The Lands' Improvement Company is not an operative company, but simply repays a landowner the amount expended on approved works. A limited contract is, however, necessary before-hand with each.

When referring to these advantages, as inductive of improvement and economy, it would be well to turn to the great desideratum of applying machinery wherever it is possible to apply it in the operations of draining. As much improvement has already been effected in the manufacture of pipes by the use of machinery as it is likely will be effected for some years to come. But we have profited very little by the application of machinery to the cutting of drains, although the increased and still increasing price of spade-labour makes the item in the cost of under-draining a matter of grave consideration, when war and emigration are reducing the working population as sensibly as at present is the case ; as I know from the circumstance of having to pay weekly between 1500 and 1700 men now employed by the General Land Drainage Company. But irrespective of these causes, draining labourers are becoming fewer in consequence of the demand for hands in the general service of farming, and this grateful fact must lead sooner or later to the adoption of a substitute for the spade in soils in which mechanical appliances may be adopted without risk.

The agricultural body are already much indebted to the

perseverance with which Mr. Fowler of Bristol has submitted his draining plough to the scrutiny of the public, as from time to time he has improved it, and although certain disadvantages still prevent its use on estates to be charged for a long period of years with the cost of drainage works, there can be no doubt as practice makes perfect, and now that steam-power has taken the place of horse-power, that the hesitation prevailing against its use will give way, and we shall find the draining plough, or some other superior machine, adopted in all uniform clay soils, with regular inclination of surface where the parallel system is strictly applied. At present objections are raised to Fowler's plough on the following grounds:—

1st. That it does not obtain a regular fall for the drains in lands of uneven surfaces, and in lands of the high ridge and furrow form.

2nd. That it does not preserve a regular fall, nor can be profitably worked in rocky land, or lands subject to large bolder stones.

3rd. That the bottom of the drains is not seen, and therefore there must remain a doubt on the mind whether the continuity of the pipes is preserved throughout.

Mr. Fowler has very lately contrived, however, a means of securing a regular fall which may overcome the first objection, and he confines his operations, I believe, to uniform clays with regular surfaces, and with increasing success, whereby he avoids the chances of defects—and, what is equally to be avoided, the costly evil of uniformity in soils of mixed character and of sudden differences of elevation, to which, as I have before shown, mechanical and uniform arrangements are inapplicable.

Having dwelt so long upon systems in practice and systems abrogated, it will appear anomalous now at the end of my paper to admit that we have one and all been disregarding the primary step towards systematic drainage, if not its very germ, without which isolated instances of perfect detail are but so many elements of discord. I refer to the arterial drainage of the country—the management of the numberless watercourses which are the

receivers of the water discharged from the soil by underdrains. As far back as the year 1842, before the publication of Mr. Smith's (Deanston) pamphlet on thorough draining, I ventured, in the pages of the Westminster Review, to point out the necessity of providing for the more rapid and direct discharge of surface waters by underdraining, in anticipation of the evils which are daily becoming more and more apparent and abundant, as the practice of underdraining extends; and I cannot therefore lose the opportunity of reiterating the sentiments I then expressed, and which all observant men interested in the subject will confirm.

Our various unconnected works of underdraining are leading to a supreme state of disorganisation.

"It would appear that the only object aimed at in the operations that have produced these results, has been to get rid of the injurious waters by the cheapest possible course, without any consideration of the fact that water set free above commits injury below, unless it be securely guided to its ultimate discharge.

"There is no doubt that the altered condition of surface soils after effective underdraining is opposed to evaporation, and it is equally clear that the more free and open the soil operated upon, the more rapid will be the action of underdraining, and the greater the quantity of water arrested from the atmosphere by the drainage, so that in proportion to the benefit derived by one landowner may another be injured, if accident has placed the property of the one at a higher level than that of the other. That such injuries do result is proved by the disputes, and litigation, and efforts of retaliation, which are becoming daily more frequent as the present unconnected works gain ground.

"But this is not the worst. Legal strife might probably beget a legal remedy; but in order to avoid such annoyances, shallow and inefficient drainage very often has been carried out in lands approaching the outfalls, under the plea of an incapability of improving them without the co-operation of others who either negative such a proposal or remain passive, in order that the first promoter may bear the whole expense of the work.

"This is radically wrong. As we would cut a single drain, or drain a single field, by beginning at the lowest end of the one, and at the outlet of the other, in order to give freedom to incoming waters, which would otherwise accumulate and stop the work, so should the drainage of the entire kingdom be conducted. Every part should organise with the whole—the tidal sea with the flowing rivers; the rivers with the main tributary watercourses; the main watercourses with the outfall ditches; the outfall ditches with the outlets of the main underdrains, and the mains with minor underdrains.

"Reversing this order of operations, we have launched into a vast expenditure

of money in *underdraining*, without any consideration of the general system or ramification of works essential to an effective discharge of the water set free by underdraining."*

It is beside our object at this moment to discuss a remedy. An effort was made by Mr. Ker Seymer, in the last Session of Parliament, to pass the very valuable bill to which a cursory reference has been made. It was rejected in the House of Lords, and I now believe there is a disposition on the part of some influential members of the Government to take the matter up as a Government measure; and if so, there is some probability of a remedy being attained. It is hard to believe, but it is nevertheless the fact, that after expending millions in freeing the land of stagnant water, we have no power to widen, deepen, and straighten shallow and tortuous outfall ditches in which any objecting landowner is interested, although it may be distinctly shown that mutual benefit would result if the work could be carried out.

If a landowner desires to put Lord Lincoln's Act (10 & 11 Vict. cap. 38) into operation, even to the extent of compelling a negligent neighbour to clear out a ditch which is choked up with weeds and rubbish, the forms to be gone through, and the difficulties are such, that they operate as a veto to proceeding under it. I will not enter upon the difficult question of mills and mill-streams, though one of paramount importance to all interested in draining. The limits of the present discussion forbid its introduction, and for that reason I must postpone for another opportunity some remarks I should like to have made on several important points—such as the stoppage of drains by the growth of *grass roots*, and by the incrustation of lime within the pipes, as is known to occur in Lincolnshire and Yorkshire.

The after-treatment of drained land, and the abuse of draining by too quickly irrigating meadows after draining, are important points in connection with the subject, which ought not to be overlooked when we are speaking of results; but these points

* Extract from published Letter to Philip Pusey, Esq., by the Writer.

must be deferred for another occasion. I cannot, however, close this paper, without thanking my many correspondents for the trouble they have taken in affording me information.

Having endeavoured to place before you a statement of the results arrived at from the several systems of drainage in practice, as far as my time and ability would allow me to collect them, I have only one further remark to make; I have found the inquiry too extensive and complicated for a man actively engaged in business to do justice to, and I must therefore plead excuses for omissions; but I am sanguine enough to believe that the little I have put before you will warrant my anticipating one conclusion to which we shall come—viz., that there still exists a conflict of opinions and a difference in practice on certain elementary points, where there would exist no difference in opinion nor practice, if facts were elicited and the results of past experience obtained and recorded by unprejudiced and competent authority.

There are other points, however, upon which there must ever remain a difference of practice, if not of opinion, but upon which much information could be gained from past experience, with benefit to the country at large. It, therefore appears to me, that the subject is one quite worthy the attention of the Government, and that as the Legislature has constituted a branch of the Executive Government the protectors of reversionary interests of settled estates, the Government is the proper authority to institute an inquiry into the whole practice of draining, with a view to set at rest, as far as possible, conflicting opinions, and to afford decisive data upon those points of practice where data can be given. And it is not anticipating too much to believe that from such an inquiry would spring a measure for the improvement of arterial drainage as a fundamental object.

52, PARLIAMENT STREET, WESTMINSTER,
20th December, 1854.

TABLE I.—*Cost of Draining per Acre at different intervals between Drains at different Prices for Labour and Materials.*

When ordinary Agricultural Labour is considered to be fairly paid, at a weekly wage of 10s., the labourer engaged in draining and finding his own tools should be able to earn 13s. 6d. per week. — Pipes for minor drains, supposing half to be 1½ inch and half 2 inch pipes, may be taken at an average cost of 17s. 6d. per 1000. When the value of Agricultural labour is represented at 12s. a week, the draining labourer should earn 16s. 2d., and pipes will be found to average 20s. per 1000. And when Agricultural labour is represented by 14s. a week, the draining labourer should earn 19s., and then pipes will rise to 22s. 6d. In giving the above average cost of materials, those districts are excluded from consideration where clay suitable for pipes exists in the immediate vicinity of coal pits, which must necessarily reduce the cost of producing them very considerably.

	18 ft. apart.	21 ft. apart.	24 ft. apart.	27 ft. apart.	30 ft. apart.	40 ft. apart.	50 ft. apart.	60 ft. apart.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Labour, cutting, and filling in, at 6d. per rod	3 18 4	3 2 10	2 15 0	2 8 11	2 4 0	1 13 0	1 6 5	1 2 0
Materials, pipes for minor drains, 18s. per 1000	2 5 9	1 19 2	1 14 3	1 10 6	1 7 5	1 0 6	0 16 5	0 13 8
Haulage, 2 miles, and delivery in fields, at 2s. 6d. per 1000	0 6 4	0 5 5	0 4 9	0 4 3	0 3 9	0 2 9	0 2 3	0 2 0
Pipe-laying and finishing, 1d. per rod	0 12 2	0 10 6	0 9 2	0 8 2	0 7 4	0 5 6	0 4 5	0 3 8
Superintendence, Foreman.	0 5 0	0 5 0	0 5 0	0 5 0	0 5 0	0 4 0	0 3 0	0 3 0
Extra for mains	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0
Iron outlet pipes and masonry and extra labour.	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6
Total	7 6 1	6 6 5	5 11 8	5 0 4	4 11 0	3 9 3	2 16 0	2 7 10
Add for collars if used	1 2 10	0 19 7	0 17 1	0 15 3	0 13 8	0 10 3	0 8 2	0 6 10
Total	8 8 11	7 6 0	6 8 9	5 15 7	5 4 8	3 19 6	3 4 2	2 14 8
Labour, at 7d. per rod	4 5 6	3 13 4	3 4 2	2 17 0	2 11 4	1 18 6	1 10 10	1 5 8
Materials, 20s. per 1000	2 10 10	2 3 6	1 18 1	1 13 10	1 10 6	1 2 10	0 18 3	0 15 3
Haulage, 2s. 6d. per 1000	0 6 4	0 5 5	0 4 9	0 4 3	0 3 9	0 2 9	0 2 3	0 2 0
Pipe-laying, 1d. per rod	0 12 2	0 10 6	0 9 2	0 8 2	0 7 4	0 5 6	0 4 5	0 3 8
Superintendence	0 5 0	0 5 0	0 5 0	0 5 0	0 5 0	0 4 0	0 3 0	0 3 0
Extra for mains	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0	0 2 0
Iron outlets and masonry	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6	0 1 6
Total	8 3 4	7 1 3	6 4 8	5 11 9	5 1 5	3 17 1	3 2 3	2 13 1
Add for collars, if used	1 5 5	1 1 9	0 19 0	0 16 11	0 15 3	0 11 5	0 9 1	0 7 7
Total	9 8 9	8 3 0	7 3 8	6 8 8	5 16 8	4 8 6	3 11 4	3 0 8
Labour at 8d. per rod.	4 17 9	4 3 9	3 13 4	3 5 2	2 18 8	2 4 0	1 15 3	1 9 4
Materials, 21s. per 1000.	2 13 7	2 6 3	2 0 10	1 16 7	1 13 3	1 5 7	1 1 0	0 16 1
Haulage, 2s. 6d. per 1000	0 6 4	0 5 5	0 4 9	0 4 3	0 3 9	0 2 9	0 2 3	0 2 0
Pipe-laying, 1d. per rod	0 12 2	0 10 6	0 9 2	0 8 2	0 7 4	0 5 6	0 4 5	0 3 8
Superintendence	0 5 0	0 5 0	0 5 0	0 5 0	0 5 0	0 4 0	0 3 0	0 3 0

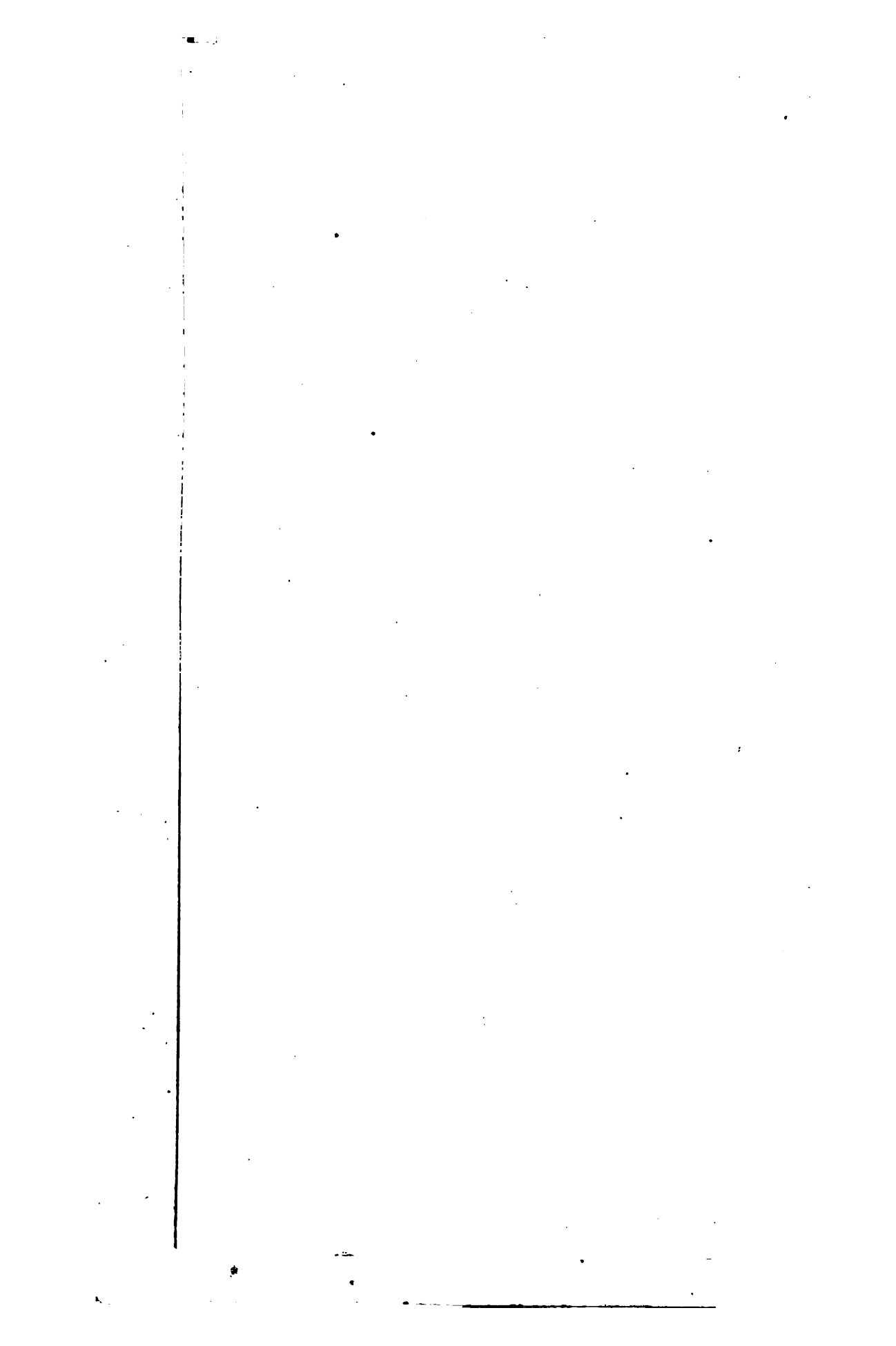
TABLE II.—Table showing the equal Annual Amount of Principal combined mentioned Rates of Interest, in any period of from one to Fifty legalises a charge upon Entailed Estates.

No. of years in which Loans to be repaid.	8 per cent. per annum.						3½ per cent. per annum.						4 per cent. per annum.					
	Average Annual Instalment of Principal and Interest.						Average Annual Instalment of Principal and Interest.						Average Annual Instalment of Principal and Interest.					
	£1			£100			£1			£100			£1			£100		
	s.	d.		£	s.	d.	s.	d.		£	s.	d.	s.	d.		£	s.	d.
1	1-0300	20	7½	103	0	0	1-0350	20	8½	103	10	0	1-0400	20	9½	104	0	0
2	·5226	10	5½	52	5	2½	·5264	10	6½	52	12	9½	·5301	10	7½	53	0	4½
3	·3535	7	0½	35	7	0½	·3569	7	1½	35	13	10½	·3603	7	2½	36	0	8½
4	·2690	5	4½	26	18	0½	·2722	5	5½	27	4	6	·2754	5	6	27	10	11½
5	·2183	4	4½	21	16	8½	·2214	4	5½	22	2	11½	·2246	4	6	22	9	3
6	·1845	3	8½	18	9	2½	·1876	3	9	18	15	4	·1907	3	9½	19	1	6½
7	·1605	3	2½	16	1	0½	·1635	3	3½	16	7	1	·1666	3	4	16	13	2½
8	·1424	2	10½	14	4	11	·1454	2	11	14	10	11½	·1485	2	11½	14	17	0½
9	·1284	2	6½	12	16	10½	·1314	2	7½	13	2	10½	·1344	2	8½	13	8	11½
10	·1172	2	4½	11	14	5½	·1202	2	4½	12	0	5½	·1239	2	5½	12	6	7
11	·1080	2	2	10	16	1½	·1110	2	2½	11	2	2½	·1141	2	3½	11	8	3½
12	·1004	2	0	10	0	11	·1034	2	0½	10	6	11½	·1065	2	1½	10	13	1½
13	·0940	1	10½	9	8	0½	·0970	1	11½	9	14	1½	·1001	2	0	10	0	3½
14	·0885	1	9½	8	17	0½	·0915	1	10	9	3	1½	·0946	1	10½	9	9	4
15	·0837	1	8	8	7	6½	·0868	1	8½	8	13	7½	·0899	1	9½	8	19	10½
16	·0796	1	7½	7	19	2½	·0826	1	7½	8	5	4½	·0858	1	8½	8	11	7½
17	·0759	1	6½	7	11	10½	·0790	1	7½	7	18	1	·0821	1	7½	8	4	4½
18	·0727	1	5½	7	5	5	·0758	1	6½	7	11	7½	·0789	1	7	7	17	11½
19	·0698	1	4½	6	19	7½	·0729	1	5½	7	5	10½	·0761	1	6½	7	12	3½
20	·0672	1	4½	6	14	5½	·0703	1	5	7	0	8½	·0735	1	5½	7	7	2
21	·0648	1	3½	6	9	9	·0680		4½	6	16	1	·0712	1	5	7	2	6½
22	·0627	1	3	6	5	6	·0659	1	3½	6	11	10½	·0691	1	4½	6	18	4½
23	·0608	1	2½	6	1	7½	·0640	1	3½	6	8	0½	·0673	1	4½	6	14	7½
24	·0590	1	2½	5	18	1½	·0622	1	3	6	4	6½	·0655	1	3½	6	11	2
25	·0574	1	1½	5	14	10½	·0606	1	2½	6	1	4½	·0640	1	3½	6	8	0½
26	·0559	1	1½	5	11	10½	·0592	1	2½	5	18	5	·0625	1	3	6	5	1½
27	·0545	1	1	5	9	1½	·0578	1	2	5	15	8½	·0612	1	2½	6	2	5½
28	·0532	1	0½	5	6	7	·0566	1	1½	5	13	2½	·0600	1	2½	6	0	0½
29	·0521	1	0½	5	4	2½	·0554	1	1½	5	10	10½	·0588	1	2	5	17	7½
30	·0510	1	0½	5	2	0½	·0543	1	1	5	8	9	·0578	1	1½	5	15	8
31	·0500	1	0	5	0	0	·0534	1	0½	5	6	9½	·0569	1	1½	5	13	9
32	·0490	0	11½	4	18	0	·0524	1	0½	5	4	9½	·0559	1	1½	5	11	11
33	·0482	0	11½	4	16	4½	·0516	1	0½	5	3	2½	·0551	1	1	5	10	3
34	·0473	0	11½	4	14	7	·0508	1	0½	5	1	7	·0543	1	1	5	8	8
35	·0465	0	11	4	13	0	·0500	1	0	5	0	0	·0536	1	0½	5	7	2
36	·0458	0	10½	4	11	7	·0493	0	11½	4	18	7	·0529	1	0½	5	5	8
37	·0451	0	10½	4	10	2½	·0486	0	11½	4	17	2½	·0522	1	0½	5	4	6
38	·0445	0	10½	4	9	0	·0480	0	11½	4	16	0	·0516	1	0½	5	3	3
39	·0438	0	10½	4	7	7	·0474	0	11½	4	14	9½	·0511	1	0½	5	2	2
40	·0433	0	10½	4	6	7	·0469	0	11½	4	13	9½	·0505	1	0	5	1	1
41	·0427	0	10	4	5	4½	·0463	0	11	4	12	7	·0500	1	0	5	0	1
42	·0422	0	10	4	4	4½	·0458	0	10½	4	11	7	·0495	0	11½	4	19	1
43	·0417	0	10	4	3	4½	·0454	0	10½	4	10	9½	·0491	0	11½	4	18	2
44	·0412	0	9½	4	2	4½	·0449	0	10½	4	9	9½	·0487	0	11½	4	17	4
45	·0408	0	9½	4	1	7	·0445	0	10½	4	9	0	·0483	0	11½	4	16	7
46	·0404	0	9½	4	0	9½	·0441	0	10½	4	8	2½	·0479	0	11½	4	15	9
47	·0400	0	9½	4	0	0	·0437	0	10½	4	7	4½	·0475	0	11½	4	15	1
48	·0396	0	9½	3	19	2½	·0434	0	10½	4	6	9½	·0472	0	11½	4	14	5
49	·0392	0	9½	3	18	4½	·0430	0	10½	4	6	0	·0469	0	11	4	13	9
50	·0389	0	9½	3	17	9½	·0427	0	10	4	5	4½	·0466	0	11	4	13	1

with Interest which is requisite for the Repayment of Loans, at the under-
Years, the period for which the General Land Drainage Company's Act

4½ per cent. per annum.				5 per cent. per annum.				6 per cent. per annum.				No. of years in which Loans to be repaid.
Average Annual Instalment of Principal and Interest.				Average Annual Instalment of Principal and Interest.				Average Annual Instalment of Principal and Interest.				
£1		£100		£1		£100		£1		£100		
s. d.	£ s. d.	£ s. d.	s. d.	s. d.	£ s. d.	£ s. d.	s. d.	s. d.	£ s. d.	£ s. d.	s. d.	
1-0450=20 10½	104 10 0	104 10 0	0	1-0500=21 0	105 10 0	105 10 0	0	1-0600=21 2½	106 0 0	106 0 0	0	1
·5339 10 8½	53 8 0	53 8 0	0	·5378 10 9	53 15 7½	53 15 7½	0	·5454 10 11	54 10 10½	54 10 10½	0	2
·3637 7 3½	36 7 6½	36 7 6½	0	·3672 7 4½	36 14 5	36 14 5	0	·3741 7 5½	37 8 2½	37 8 2½	0	3
·2787 5 7	27 17 5½	27 17 5½	0	·2820 5 7½	28 4 0½	28 4 0½	0	·2885 5 9½	28 17 2½	28 17 2½	0	4
·2277 4 6½	22 15 7	22 15 7	0	·2309 4 7½	23 1 11½	23 1 11½	0	·2373 4 9	23 14 9½	23 14 9½	0	5
·1938 3 10½	19 7 9	19 7 9	0	·1970 3 11½	19 14 0½	19 14 0½	0	·2033 4 0½	20 6 8½	20 6 8½	0	6
·1697 3 4½	16 19 5	16 19 5	0	·1728 3 5½	17 5 7½	17 5 7½	0	·1791 3 7	17 18 3½	17 18 3½	0	7
·1516 3 0½	15 3 2½	15 3 2½	0	·1547 3 1	15 9 5½	15 9 5½	0	·1610 3 2½	16 2 0½	16 2 0½	0	8
·1375 2 9	13 15 1½	13 15 1½	0	·1406 2 9½	14 1 4½	14 1 4½	0	·1470 2 11½	14 14 0½	14 14 0½	0	9
·1263 2 6½	12 12 9	12 12 9	0	·1295 2 7	12 19 0	12 19 0	0	·1358 2 8½	13 11 9	13 11 9	0	10
·1172 2 4½	11 14 6	11 14 6	0	·1203 2 5	12 0 9½	12 0 9½	0	·1267 2 6½	12 13 7	12 13 7	0	11
·1096 2 2½	10 19 4	10 19 4	0	·1128 2 3	11 5 7½	11 5 7½	0	·1192 2 4½	11 18 6½	11 18 6½	0	12
·1032 2 0½	10 6 6½	10 6 6½	0	·1064 2 1½	10 12 11	10 12 11	0	·1129 2 3	11 5 11	11 5 11	0	13
·0978 1 11½	9 15 7½	9 15 7½	0	·1010 2 0½	10 2 0½	10 2 0½	0	·1075 2 1½	10 15 2	10 15 2	0	14
·0931 1 10½	9 6 2½	9 6 2½	0	·0963 1 11½	9 12 8½	9 12 8½	0	·1029 2 0½	10 5 11½	10 5 11½	0	15
·0890 1 9½	8 18 0½	8 18 0½	0	·0922 1 10½	9 4 6½	9 4 6½	0	·0989 1 11½	9 17 11	9 17 11	0	16
·0854 1 8½	8 10 10	8 10 10	0	·0886 1 9½	8 17 4½	8 17 4½	0	·0954 1 11	9 10 10½	9 10 10½	0	17
·0822 1 7½	8 4 5½	8 4 5½	0	·0855 1 8½	8 11 1	8 11 1	0	·0923 1 10½	9 4 8½	9 4 8½	0	18
·0794 1 7	7 18 9½	7 18 9½	0	·0827 1 7½	8 5 5½	8 5 5½	0	·0896 1 9½	8 19 3	8 19 3	0	19
·0768 1 6½	7 13 9	7 13 9	0	·0802 1 7½	8 0 5½	8 0 5½	0	·0871 1 9	8 14 4½	8 14 4½	0	20
·0746 1 6	7 9 2½	7 9 2½	0	·0779 1 6½	7 16 0	7 16 0	0	·0850 1 8½	8 10 0	8 10 0	0	21
·0725 1 5½	7 5 1	7 5 1	0	·0759 1 6½	7 11 11½	7 11 11½	0	·0830 1 8	8 6 1	8 6 1	0	22
·0706 1 5	7 1 4½	7 1 4½	0	·0741 1 5½	7 8 3½	7 8 3½	0	·0812 1 7½	8 2 6½	8 2 6½	0	23
·0689 1 4½	6 17 11½	6 17 11½	0	·0724 1 5½	7 4 11½	7 4 11½	0	·0796 1 7½	7 19 4½	7 19 4½	0	24
·0674 1 4½	6 14 10½	6 14 10½	0	·0709 1 5	7 1 11	7 1 11	0	·0782 1 6½	7 16 5½	7 16 5½	0	25
·0660 1 4	6 12 0½	6 12 0½	0	·0695 1 4½	6 19 1½	6 19 1½	0	·0769 1 6½	7 13 9½	7 13 9½	0	26
·0647 1 3½	6 9 5½	6 9 5½	0	·0682 1 4½	6 16 7	6 16 7	0	·0756 1 6½	7 11 4½	7 11 4½	0	27
·0635 1 3½	6 7 0½	6 7 0½	0	·0671 1 4½	6 14 3	6 14 3	0	·0745 1 6	7 9 2½	7 9 2½	0	28
·0624 1 3	6 4 10	6 4 10	0	·0660 1 4	6 12 1	6 12 1	0	·0735 1 5½	7 7 2	7 7 2	0	29
·0613 1 2½	6 2 9½	6 2 9½	0	·0650 1 3½	6 10 1½	6 10 1½	0	·0726 1 5½	7 5 3½	7 5 3½	0	30
·0605 1 2½	6 0 11	6 0 11	0	·0641 1 3½	6 8 8	6 8 8	0	·0718 1 5½	7 3 7½	7 3 7½	0	31
·0596 1 2	5 19 2	5 19 2	0	·0633 1 3½	6 6 7	6 6 7	0	·0710 1 5	7 2 0	7 2 0	0	32
·0588 1 2	5 17 6	5 17 6	0	·0625 1 3	6 5 0	6 5 0	0	·0703 1 4½	7 0 7	7 0 7	0	33
·0580 1 1½	5 16 0	5 16 0	0	·0618 1 2½	6 3 6	6 3 6	0	·0696 1 4½	6 19 2½	6 19 2½	0	34
·0573 1 1½	5 14 7	5 14 7	0	·0611 1 2½	6 2 2	6 2 2	0	·0690 1 4½	6 18 0	6 18 0	0	35
·0566 1 1½	5 13 3	5 13 3	0	·0604 1 2½	6 0 11	6 0 11	0	·0684 1 4½	6 16 9½	6 16 9½	0	36
·0560 1 1½	5 12 0	5 12 0	0	·0598 1 2½	5 19 8	5 19 8	0	·0679 1 4	6 15 9½	6 15 9½	0	37
·0554 1 1½	5 10 10	5 10 10	0	·0593 1 2	5 18 7	5 18 7	0	·0674 1 4	6 14 9½	6 14 9½	0	38
·0549 1 1	5 9 8	5 9 8	0	·0588 1 1½	5 17 7	5 17 7	0	·0669 1 3½	6 13 9	6 13 9	0	39
·0544 1 1	5 8 8	5 8 8	0	·0583 1 1½	5 16 7	5 16 7	0	·0665 1 3½	6 13 0	6 13 0	0	40
·0539 1 1	5 7 9	5 7 9	0	·0578 1 1½	5 15 8	5 15 8	0	·0661 1 3½	6 12 2½	6 12 2½	0	41
·0534 1 0½	5 6 10	5 6 10	0	·0574 1 1½	5 14 10	5 14 10	0	·0657 1 3½	6 11 4½	6 11 4½	0	42
·0530 1 0½	5 6 0	5 6 0	0	·0570 1 1½	5 14 0	5 14 0	0	·0653 1 3½	6 10 7½	6 10 7½	0	43
·0526 1 0½	5 5 2	5 5 2	0	·0566 1 1½	5 13 3	5 13 3	0	·0650 1 3½	6 10 0	6 10 0	0	44
·0523 1 0½	5 4 5	5 4 5	0	·0563 1 1½	5 12 7	5 12 7	0	·0647 1 3½	6 9 4½	6 9 4½	0	45
·0519 1 0½	5 3 9	5 3 9	0	·0559 1 1½	5 11 11	5 11 11	0	·0644 1 3½	6 8 9½	6 8 9½	0	46
·0515 1 0½	5 3 1	5 3 1	0	·0556 1 1½	5 11 3	5 11 3	0	·0641 1 3½	6 8 2½	6 8 2½	0	47
·0512 1 0½	5 2 5	5 2 5	0	·0553 1 0	5 10 8	5 10 8	0	·0639 1 3½	6 7 9½	6 7 9½	0	48
·0509 1 0	5 1 10	5 1 10	0	·0550 1 0	5 10 1	5 10 1	0	·0637 1 3	6 7 4½	6 7 4½	0	49
·0507 1 0	5 1 3	5 1 3	0	·0548 1 0	5 9 7	5 9 7	0	·0634 1 3	6 6 9½	6 6 9½	0	50

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